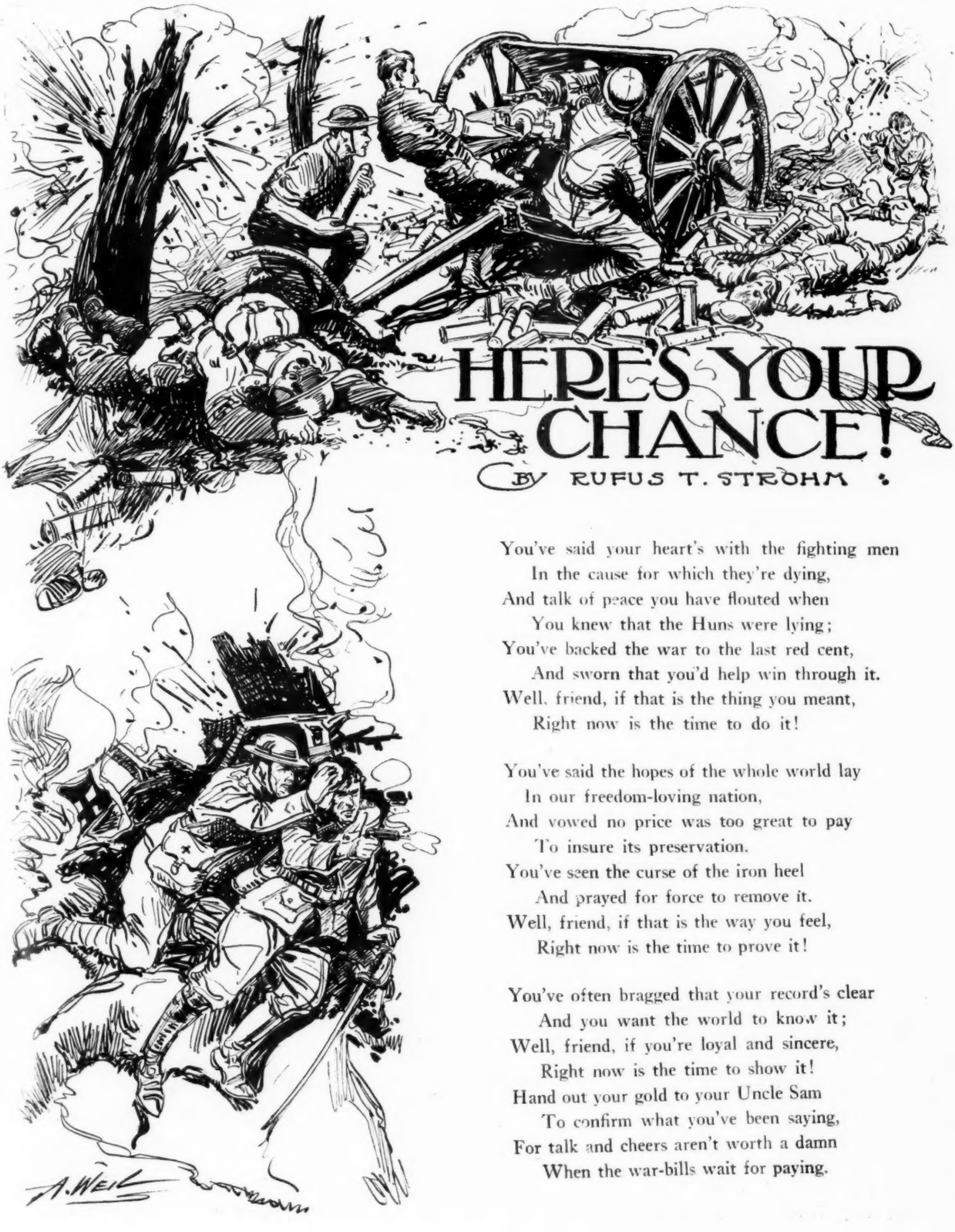
POWER

Volume 48 New York, October 8, 1918 *Number* 15



HERE'S YOUR CHANCE!

BY RUFUS T. STROHM

You've said your heart's with the fighting men
In the cause for which they're dying,
And talk of peace you have flouted when
You knew that the Huns were lying;
You've backed the war to the last red cent,
And sworn that you'd help win through it.
Well, friend, if that is the thing you meant,
Right now is the time to do it!

You've said the hopes of the whole world lay
In our freedom-loving nation,
And vowed no price was too great to pay
To insure its preservation.
You've seen the curse of the iron heel
And prayed for force to remove it.
Well, friend, if that is the way you feel,
Right now is the time to prove it!

You've often bragged that your record's clear
And you want the world to know it;
Well, friend, if you're loyal and sincere,
Right now is the time to show it!
Hand out your gold to your Uncle Sam
To confirm what you've been saying,
For talk and cheers aren't worth a damn
When the war-bills wait for paying.

Disastrous Flywheel Explosion at Chicago

AT 2 p.m. on the afternoon of Sept. 19 a large flywheel exploded in engine room No. 1 of the Chicago Coated Board Co., killing one man, the oiler, wrecking two other engines and doing damage estimated at $20,000. The engine to which the flywheel was attached was a 24 x 42-in. 500-hp. simple Corliss, making 108 r.p.m. The shaft extended to an outboard bearing to carry a 9-ton flywheel 14 ft. 6 in. diameter with a 38-in. face. The flywheel had six spokes. It had been cast in halves and bolted together at the hub and rim. Four 2½-in. bolts held the hub and four 2-in. bolts were used at each rim joint. The metal in the rim was 1½ in. thick. At each edge was a 3-in. flange and at the center a heavy reinforcement 5-in. deep. These measurements were from the outer face of the wheel.

With the flywheel serving as a belt pulley the engine had been driving a long line of shafting on the first floor in the beater room, and immediately beside it was a duplicate engine driving another line of shafting in the basement. The operating steam pressure was 150 lb. gage and as the exhaust steam was used in driers and for process work, there was a back pressure of 9 lb. The engines were thoroughly protected against overspeeding. Each had a flyball governor equipped with the usual safety stop and in addition an engine stop arranged to be operated mechanically or electrically. There were, therefore, adequate safety appliances.

Evidence from the beater room and elsewhere would tend to show that it was not overspeed that caused the accident. The engine was running along as usual at about 65 per cent. of rating with the throttle two turns open. The load was constant and the speed normal. The engineer had just stepped out into the boiler room. His attention was first aroused by the noise of escaping steam and immediately after by the commotion caused by the flying parts of the wheel. Fragments would be a better word, for with the exception of two pieces, one containing two spokes and the intervening rim and the other a single spoke, the flywheel had been broken to bits. The greater number went upward, carrying the engine-room roof with them. Two rim pieces adjacent to the joint landed a full block away. Others put a hole in the house service tank on the adjoining roof and badly dented a steel tank near-by. For the most part, however, the fragments returned to the engine room, the largest of all, the two-spoke piece, dropping on the companion engine, breaking the frame near the pillow block and the eccentric reach-rod bracket—then rolling into the flywheel pit and jamming the wheel so that one spoke cracked all the way through in two places about two feet apart. On its way down this same piece struck and bent the conduit carrying the chain by which the engine stop was operated. This shut off the steam to this unit so that the engine made only three-quarters

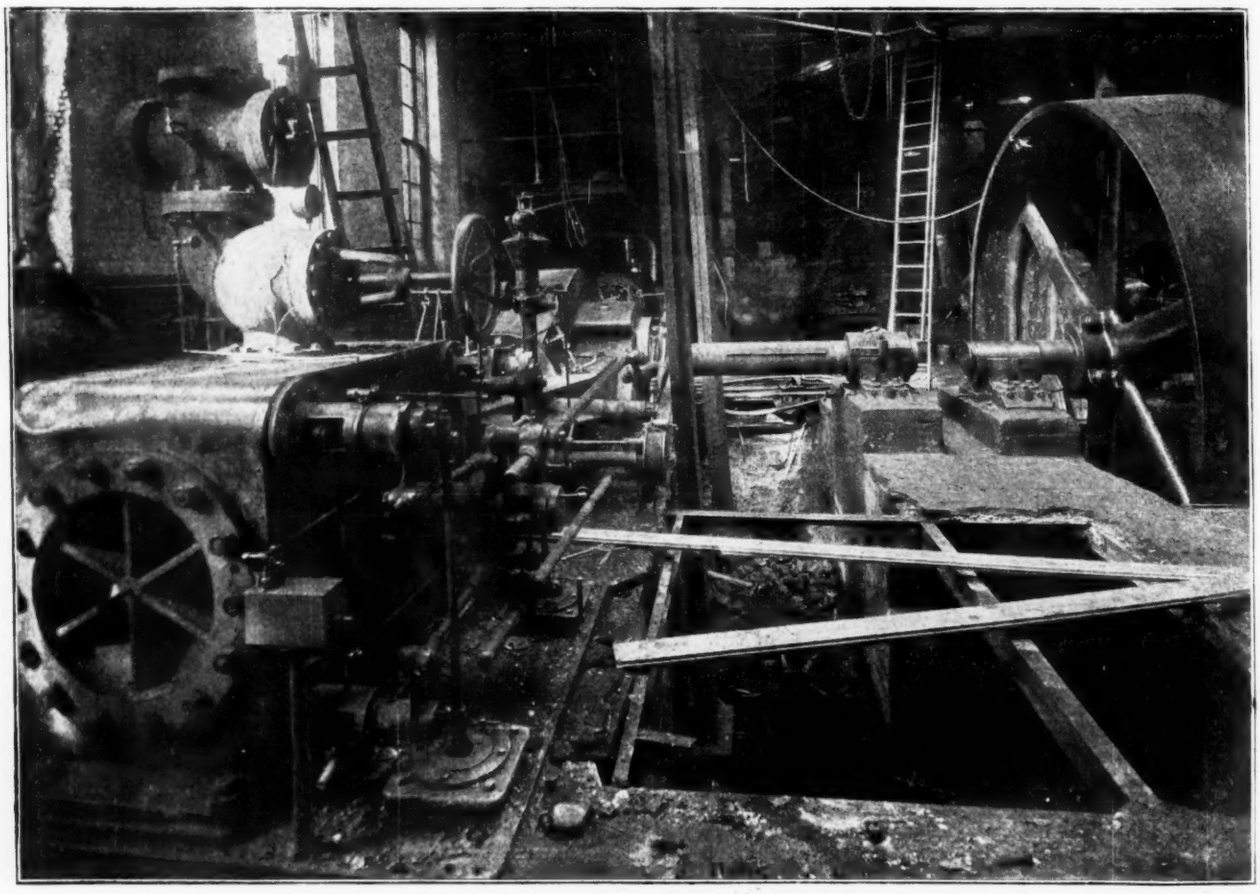


FIG. 1. VIEW OF THE ENGINE THE FLYWHEEL OF WHICH EXPLODED

FIG. 2. LARGE AND SMALL PIECES OF THE DAMAGED FLYWHEEL

of a turn after the broken part from the other engine landed in the flywheel pit.

A 50-kw. high-speed direct-connected engine in the same room suffered to the extent that its flywheel was broken in two and the governor smashed. The unit kept on running by its own momentum until it finally stopped. The engineer, being in the boiler room, immediately closed the valve on the header.

Strange to say, the engine to which the ruptured flywheel belonged is intact. It was not damaged in the least and will be ready to run as soon as a new flywheel is put in place. In fact, it was the intention to transfer to it the flywheel of the broken duplicate engine until the cracks in the spoke were discovered. Its steam-supply line had been ruptured, in the opinion of the engineer, the instant before the main part of the flywheel let go, so that for lack of driving power the engine stopped almost immediately.

Based upon the observations of the engineer, the theory is advanced that a small part of the rim first let go, severing the steam pipe, as the noise of escaping steam was first heard. This so badly unbalanced and weakened the wheel that it could not withstand the strain imposed by the peripheral velocity of 4920 ft.

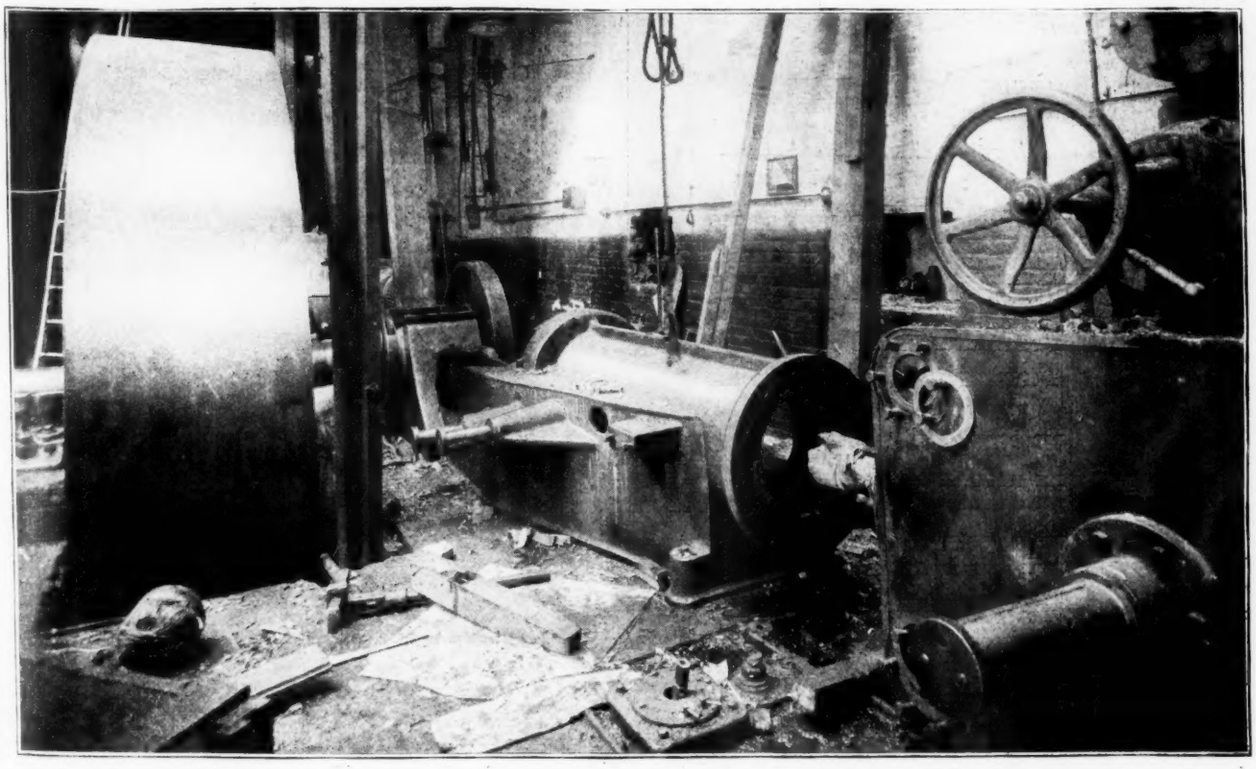


FIG. 3. ENGINE WRECKED BY EXPLODED FLYWHEEL OF THE ENGINE SHOWN IN FIG. 1

per min. that would obtain in a 14.5-ft. wheel making 108 turns per minute. All breaks were clean and no defects apparent. The hub bolts were sheared off at the nuts and the rim bolts were intact and without a mark, with the exception of one that showed signs of having been battered.

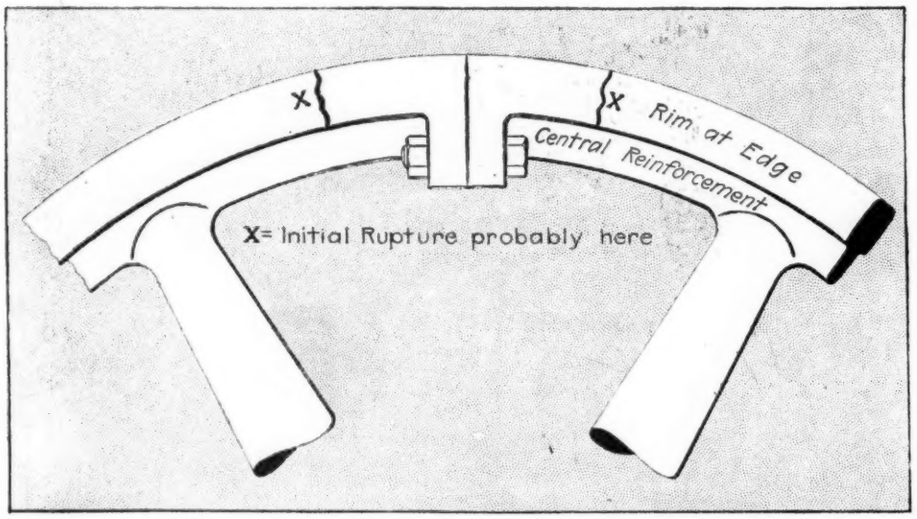


FIG. 4. WHERE INITIAL RUPTURE PROBABLY OCCURRED

In cast-iron rims of the section already indicated having unequal thicknesses of metal, severe internal stresses may be set up by uneven cooling in the mold. There were no signs of blowholes or other defects. Even if the metal were perfect, the design of the wrecked wheel is the weakest of the four general types made. As will have been inferred from the description, the wheel was made in two parts with flanged and bolted rim joints located between the arms. Being a belt wheel further weakens it to a point where, according to Kent, the joints average only one-fifth the strength of the rim and no joint of this type can be designed having a strength greater than one-fourth that of the rim. This may be compared to 50 per cent. for the pad joint and 60 per cent. of the strength of a solid rim for the link joint.

As the soundness of cast-iron rims is uncertain, a tensile strength of 10,000 lb. per sq.in. is as much as may be assumed with safety. The usual factor of safety of 10 would give a maximum allowable strain in the rim of 1000 lb. per sq.in. corresponding to a rim velocity of 6085 ft. per min., or practically 100 ft. per second. This applies to wheels made in one piece. Wheels made in sections can be no stronger than the joints, and in the present case the joint reduces the strength to one-quarter of that possessed by a solid rim.

Concentrating the weight of the bolt flanges at the center of the arc between the arms is a bad feature of this design and in part accounts for the low strength allowance. The flanges are 7 in. deep from the inside of the rim, 3 in. wide and 38 in. long. With the bolts they add a load of about 400 lb. to a 7-in. section of the rim, the distance between arm centers being 7½ ft. Acting at the weakest part of the rim, this weight would tend to bow outward the arc of the rim between the spokes. The force would be greater when the joint was

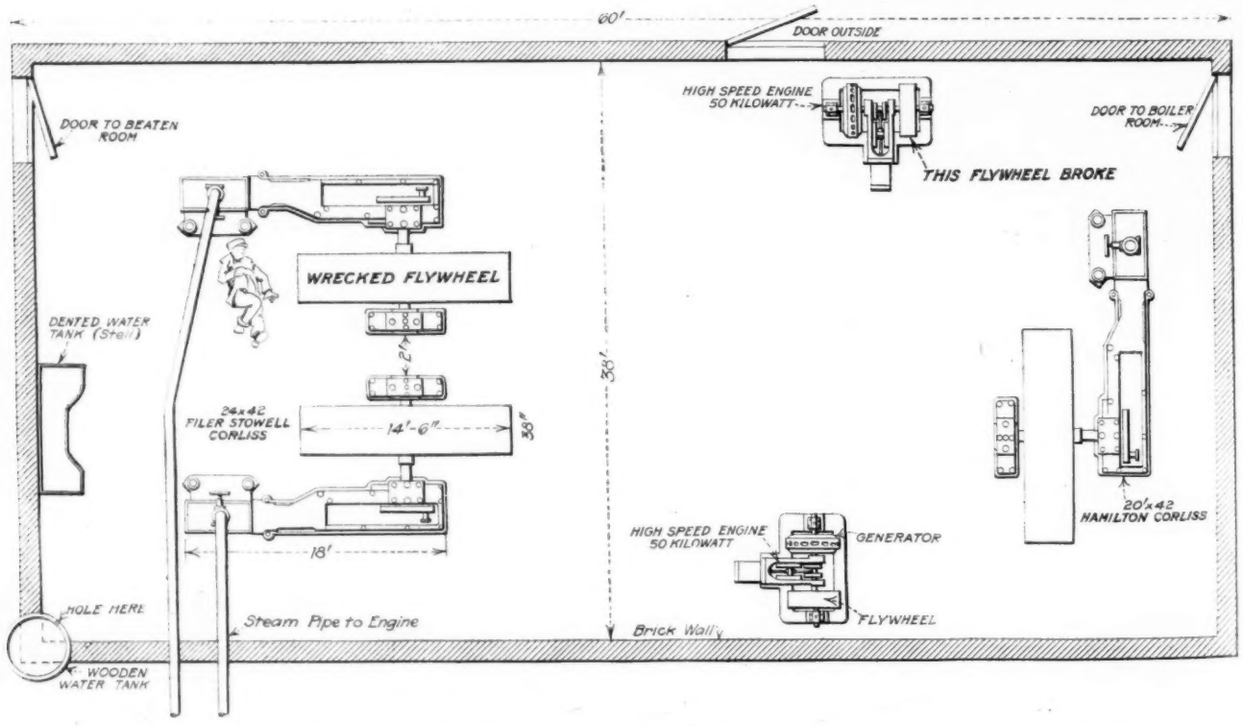


FIG. 5. LAYOUT OF ENGINE ROOM SHOWING WHERE THE OILER WAS FOUND

not supported by the belt, so that there would be a varying strain to fatigue and crystallize the metal in the rim between the joint and the arm. It is certain that the rim on either side of the two joints did break, the sections extending 8 to 15 in. back from the flange.

It is quite probable that one of these pieces let go first, rupturing the steam line to the engine and killing the oiler. With the wheel weakened and unbalanced it soon pounded itself to pieces. There was no evidence that the wheel let go all at once, as with the exception of the part that hit the steam line the pieces did not fly out tangentially in all directions. The movement for the most part was upward. The concrete in the pit gave evidence of having been badly ground. It would look as though the wheel pounded itself to pieces, the part clinging to the shaft longest scooping up the fragments and propelling them to the roof.

The engine to which the wrecked flywheel was attached had been installed five years, and the flywheel

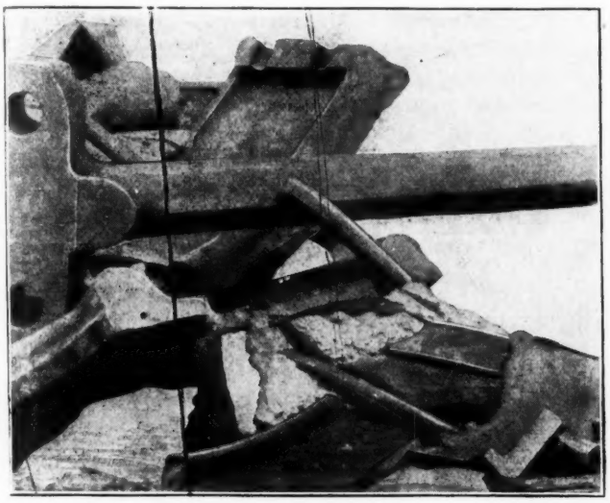


FIG. 6. BROKEN PIECES OF THE RIM FROM NEAR THE RIM JOINT

had been put on only two years ago. At that time the flywheel on the duplicate engine had exploded, with little damage and no fatalities. The flywheel of the engine now in trouble was transferred to the wrecked engine and a new flywheel, the one that ruptured on Sept. 19, was ordered to fill the vacancy. This time, however, the cause was apparent. The main driving belt had slipped off, passing under the governor and holding it up, so that the engine overspeeded. After this accident the safety stops were installed.

Three new flywheels and an engine bed have been ordered. It was expected that one of the larger engines would be running within a week after the accident and the other shortly after. The property damage was covered by insurance. The loss of time is more serious, for with the beater room down the entire mill is closed.

The War Department statisticians have figured that the cost of maintaining a soldier overseas is $423.47 a year; that it costs $327.78 to equip and maintain one in the United States. The cost of the initial equipment is $115.30 for the first year in the United States, and there is an additional outlay of $42.41 for articles issued only for overseas use.

Four-Way Equalizing Plug Valve

A four-way plug valve designed to be employed in the control of a piston using either air or water as the power medium has been perfected by W. W. Sterling, of Ruth, Nev.

Fig. 1 shows an exterior view of the valve and Fig. 2 shows sections of the plug in three positions. The lever shown is for turning the valve plug to the backward, equalizing and the forward positions. When the valve plug is in the position shown at *A*, Fig. 2, the passage of air or water is in the direction of the arrows.

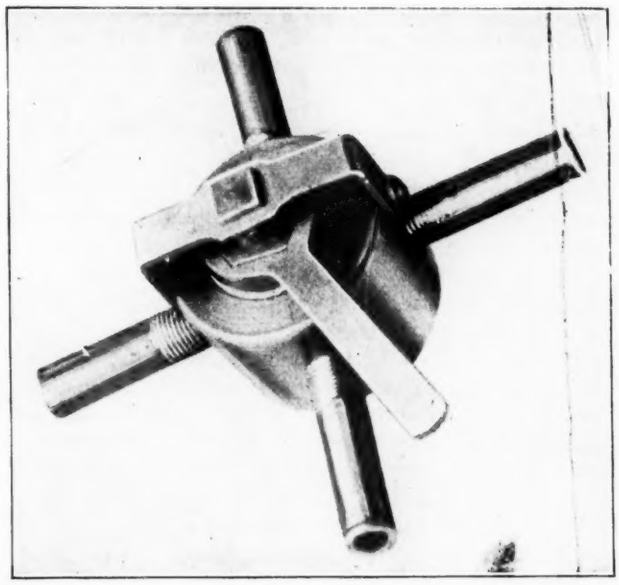


FIG. 1. EXTERIOR OF FOUR-WAY VALVE

In this position the left side of the cylinder piston is under pressure and the other side is exhausting, the equalizing port being closed.

With the lever moved to a central or equalizing position, as shown in *B*, the pressure will be the same on both sides of the piston, the equalizing ports being in line. Moving the level to the extreme right as shown in *C* admits pressure to the right end of the cylinder and

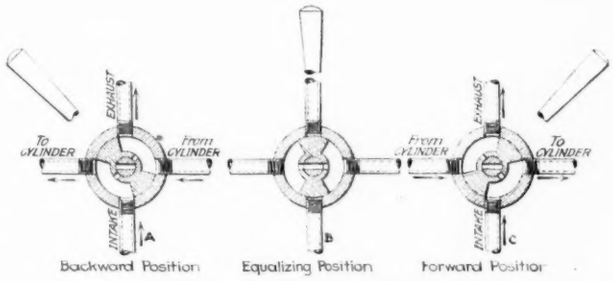


FIG. 2. SECTIONS THROUGH VALVE

opens the left end to the exhaust, the equalizing ports being closed.

By equalizing the pressure on both sides of the piston it is prevented from creeping. The valve is suitable for use on any device where the movement of the system in two directions is to be controlled by hand. The valve is simple in construction, is easily operated and occupies but little space.

Load Division Between Synchronous Frequency Changers Operating in Parallel—I

By QUENTIN GRAHAM,
Engineer, Power Division, Westinghouse Electric and Manufacturing Company

This article treats of the fundamental elements that must be considered when two or more synchronous frequency-changer sets are to be operated in parallel. For a comprehensive discussion on the construction and operation of these sets the reader's attention is called to the two articles, "Frequency-Changer Sets," published in the Oct. 16 and 30, 1917, issues of "Power."

IN ALL CASES of parallel operation the problem of load division is of prime importance. Whether the apparatus be alternating-current or direct-current generators, whether it consist of motors, steam engines or other prime movers coupled to a common load, the problem is still present; and while it may assume a different form in each of these cases and be solved in an entirely different manner, yet there is a certain similarity or analogy among its various forms. The particular problem to be dealt with here is that of determining the division of load between two synchronous frequency-changer sets which are operated in parallel on both ends.

It is assumed that the total load carried by the two sets is known and that it is required to find the way in which this load is divided between them. While the discussion given here applies to the case of two sets in parallel, it may easily be made applicable to a case of more than two sets which may or may not be similar in size or design. Before dealing directly with the operation of the complete set, it will be well to examine some of the characteristics of the individual machines.

Rotor's Position Changes With Load

When a synchronous motor is carrying load, its rotor is at any instant a few degrees behind the position it would have reached had it been running without load. The rotor's speed is the same whether loaded or without load, but its position is changed. For instance, if two identical motors were running side by side from the same source of power, an observer might notice that the poles of the two rotors were exactly in line when both machines were running free. Then, if one of the machines was loaded, he would observe that its rotor had dropped back so that the pole centers of the two machines were no longer in line, although the speeds of the two rotors would be the same. The amount of rotor shift for any given machine depends on the size of the load it is carrying and upon its excitation. In any case the shift is less than half the distance between pole centers, and the angular variation is therefore dependent on the number of poles on the rotor.

The shift of the rotor with load can be explained in a number of different ways, but as with many other electrical phenomena, a clearer conception of the action can often be gained by looking at its mechanical analogy. The generator at the power house may be likened to the driving half of a flexible coupling; the synchronous motor then becomes the driven half of the coupling. Both halves of the coupling and the shafts to which they are attached must run at the same speed at all times, but the driven half drops back a certain amount behind the driving half, depending on the amount of load transmitted and the flexibility of the springs in the coupling.

If there were two such couplings, one on each end of the driving shaft, and the same loads were being transmitted by both of them, the two driven shafts would have the same lag; but if the loads were different or if one coupling were equipped with springs that were not so stiff as those of the other, the lag of one would be different from the other. The use of springs with different degrees of stiffness is analogous to a change of excitation of the synchronous motor. Thus, if there are two identical motors carrying equal loads, the amount of shift of the rotors will be the same only as long as the field currents are the same. By overexciting a motor, as is often done in order to increase the power factor of the total load on the power plant, the amount of shift for a given mechanical load is reduced; by underexciting the motor, the shift can be made greater.

Rotor Shift as Applied to Generator

The idea of rotor shift of a synchronous motor can be extended to apply to a generator also. In this case it is easier to think of it in terms of the phase position of the voltage. If there are two identical generators running side by side without load and the pole centers of the two rotors are in a direct line, it will be found that the voltages of the two machines are exactly in phase; that is, their maximums, or their zero points, occur at the same instant. Then, if one of the generators is loaded, the poles being maintained in line as before, the voltage of the loaded machine will be found to have dropped slightly behind the other so that the maximums no longer occur at the same instant. The amount of phase difference between the voltages depends on the magnitude of the load and on its power factor. The action is the same as that which occurs in a synchronous motor and is due to the effect which the load current has on the flux distribution in the air gap.

The synchronous frequency-changer set, being an alternating-current generator of one frequency driven by a synchronous motor of another frequency, has such a shift or displacement in both machines. Let it be assumed that there are two identical sets, the motors of which are connected to the same power source, the generators of the sets are not paralleled but are running without load. Assume further that the sets are lined up so that the poles of the motors are in line, likewise the poles of the generators are also directly in line while they revolve together. If voltages of the two generators were compared, it would be found that they were exactly in phase. A synchronoscope connected to the two generators would indicate zero, which is the condition that should exist when generators are to be paralleled.

Suppose, now, that one of the generators is loaded. According to the preceding paragraphs the phase position of its voltage will change with respect to the other generator. But at the same time the motor driving the loaded generator must also drop back—that is, its rotor must shift relative to the other rotor—in the manner previously described. As a result of this there will be a double shift at the generator terminals. The rotor of the motor drops back, which, of course, means that the generator rotor that is coupled to it is caused to run slightly behind the position of the unloaded generator; then, in addition, it has its own shift of voltage relative to the position of the poles due to field distortion. Between the terminals of the loaded generator and the unloaded generator there might be, therefore, a considerable phase difference.

One point that has not yet been considered is the effect of the number of poles of the motors in comparison with the number of poles of the generators. Suppose that a certain set consists of a 4-pole motor and an 8-pole generator. When carrying a certain load the rotor shift of the motor might be one-sixth of a pole pitch or 30 electrical degrees (one pole pitch equals 180 electrical degrees), and the phase shift of the generator voltage might be the same amount, or 30 electrical degrees. When the motor drops back one-sixth of its pole pitch, the generator rotor, having twice as many poles, is carried back one-third of its pole pitch, or 60 electrical degrees. The generator, then, starts out with a handicap of 60 deg., and to that must be added its own shift of 30 deg. to get the total shift with respect to the voltage of the unloaded set. In this case, therefore, there would be a phase difference of 90 deg. between the voltages of the two generators even though the actual displacement in each of the loaded machines is only 30 electrical degrees. This may be stated mathematically: Total shift of generator voltage = (motor shift $\times \frac{\text{No. poles of generator}}{\text{No. poles of motor}}$) + Generator shift due to field distortion, where the shift of each machine and the combined shift is expressed in electrical degrees. It is evident that if the motor had twice as many poles as the generator, the total shift in the illustration used would have been 45 deg. in place of 90 degrees.

The fact has been established, so far, that a phase difference must exist between the generator voltages of a loaded and an unloaded set even though these voltages are exactly in phase when both sets are without load. It follows, naturally, that if the two sets are loaded the same amount, the shift of both generators will be the same and consequently they will be exactly in phase with each other. Under the conditions of equal loads, then, the two generators could be paralleled and there would be no disturbance whatsoever; each machine would continue to carry the same amount of load that it had carried before. The question then arises as to the result of paralleling the two generators when only one is loaded and there is as a consequence a considerable phase difference between them.

This question may be answered most readily by stating that as soon as the generators are paralleled their terminal voltages must be in phase, for when any two sources of voltage are paralleled there is a flow of current between them of such a magnitude as to bring the voltages into phase. In fact, when the two are paralleled there are no longer two voltages but only one. There must, therefore, be a flow of current between the two generators, which adds load to the one and subtracts it from the other so as to bring the generator voltages to the same phase position. It is evident, then, that the total phase shift of each set must be the same, and it has already been shown that in order to obtain equal phase shifts the loads must be the same. Stated briefly, if there be two identical sets which are arranged so that their generator voltages are in phase at no load, and if they have their fields excited equally, they may be paralleled and will take equal shares of the load at all times.

Use for Exhaust Steam in Summer

A great many plants that operate at high over-all economy during the heating season when all the exhaust steam is utilized "fall down hard" in economy when the exhaust is released to the atmosphere and wasted. One way to utilize extra exhaust, winter or summer, is to feed the boilers by means of an exhaust-steam injector. These boiler feeders are not in as general use and are not as well known and appreciated as they deserve to be.

The actual energy represented in the water entering a boiler is surprisingly small while the steam consumption of a direct-acting boiler-feed pump or an injector is, on the other hand, surprisingly great. In other words, it is not "asking much" of the steam escaping from an atmospheric exhaust pipe to do the little additional duty of putting the feed water into the boiler before leaving, considering the fact that low-pressure turbines are able to abstract about as much power out of steam taken at atmospheric pressure and exhausted to 29 in. vacuum as a good engine or turbine can get out of steam at 150 lb. initial pressure exhausted against atmospheric pressure. There is escaping from the exhaust pipe of an ordinary engine about as much energy as has been used. The energy represented in the feed water entering the boiler is at most only about one-half of one per cent. of the boiler's energy output. The heat energy, or the heat imparted to the feed water by an injector of any kind, of course, also comes from the steam and is much greater than the kinetic energy, or "kick" necessary to put the water into the boiler, and is variable as the temperature of the feed water varies. The economy of the exhaust-over the live-steam injector is found in this direction. The heat taken from the boiler in the form of steam is of course nearly all returned at once by the live-steam injector, but the exhaust-steam injector "goes one better" in returning heat to the boiler that is about to escape by way of the engine exhaust pipe.

All the water so condensed is free from scale-forming matter and therefore desirable, but care should be taken to get rid of all oil from the exhaust steam. Restarting an exhaust-steam injector is not difficult when the water flows to it under pressure or live steam is available for starting.

Senator Myers of Montana has introduced a bill to prohibit the sale of liquor within five miles of coal mines for 60 days after Oct. 1. This, he claims, will go far toward increasing production.

Some Features of Low-Compression Oil Engines—VI

By L. H. MORRISON

The reason for the injection of water into the cylinders of oil engines is discussed, and methods of cooling circulating water are described in this installment.

ORIGINALLY, water was injected for the sole purpose of preventing preignition, and it undoubtedly accomplished this object; but now numerous other advantages are claimed for it. Under heavy load, when the fuel charge is large, the stratification of the vapor, air and trapped exhaust gases is far from perfect. The temperature in the cylinder is high enough to cause ignition long before the end of compression; but if water is introduced, heat is abstracted by its vaporization and the temperature is reduced. If the amount of water admitted is properly adjusted, the fuel charge can be ignited at any desired point.

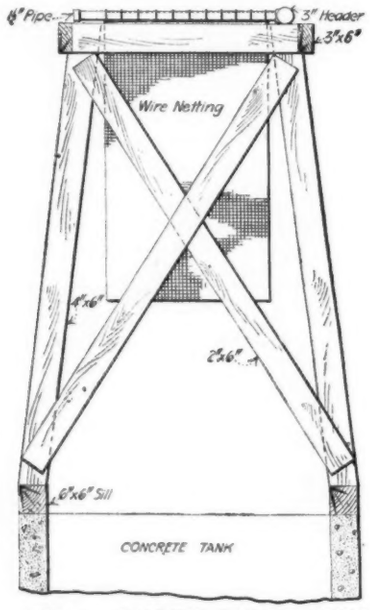


FIG. 1. COOLING TOWER USING WIRE NETTING

A few oil engines do not use water injection, thus proving that it is not necessary for the prevention of preignition; as a result, builders who do use it now claim that it increases the power output of the engine. Just how this is done is hard to determine, since the water can return to the cylinder no more heat than it absorbs.

The water also is claimed to prevent carbon deposits. This is open to question, since it is possible to find engines not using water injection that are as free from deposits as any engine of the water-injection type. Furthermore, most engines do not use water on low loads, and many of them run continuously at half load without water and without carbon deposits.

It does prevent preignition in engines in which the stratification is poor. It also assists in clearing the cylinder of exhaust gases when the exhaust port opens. This, however, is better obtained by a proper design of entrance air ports.

It has frequently been observed that engines using water injection are subject to serious cylinder wear. A great many such engines have been installed in the Southern oil fields where the sulphur content of the oil is high. It has been claimed that the wear in these engines was due to sulphuric acid resulting from the combination of sulphur and water in the cylinder. Much can be said in favor of this claim. Nevertheless, since it appears from a list of reports the writer has accumulated that such wear occurs with Eastern oils containing no sulphur, there must be another reason.

Water-Injection Opponents Claim that It Destroys Lubrication and Increases Wear

The opponents of water injection assert that it tends to wash the lubrication from the piston, and that faulty lubrication is the cause of rapid cylinder wear. From reports obtained, it would appear that rapid cylinder wear occurs in those cases where the operator has followed shop instruction as to the amount of lubricating oil to use. Since the builder usually states the minimum amount advisable, it follows that these operators did not use enough lubrication. The piston and cylinder wore rapidly, because the water washed away the oil that was used. All who reported cylinder wear mentioned that on examination the piston and cylinder were found to be dry and showed absence of lubricating oil. The majority of plants observing no undue wear reported cylinder lubrication that exceeded the average builder's guarantee by at least 100 per cent. It would appear that in these cases the water failed to wash all the oil away. That these premises are correct is borne out by a recent experience of the writer's.

In a Diesel engine plant, it had been necessary to rebush one cylinder. The cylinder was not removed, and so it was necessary to use a plain bushing and a separate "skirt" or bushing below the cylinder proper. This skirt was bolted to the mud ring and to the main bushing. Water leaks developed at the joint between the bushing and the skirt, and upon removing the piston it was found that the portion of the piston that passed the leak on the downward stroke, as well as the lower part of the cylinder, was absolutely dry, although the upper part was in fine shape. This, in the writer's judgment, proves that water injection will destroy the lubrication.

If an engine using water injection is to be purchased, automatic control of the water should be stipulated. A bleeder valve is not bad on a small engine, but on an engine of more than 25 hp. the valve should be controlled by the governor. With an ordinary bleeder valve the operator will find that he must spend much time changing the valve setting as the load changes.

A good many oil engines, especially in the sizes be-

low 50 hp., are installed with cooling tanks. This may be permissible with engines of from 15 to 25 hp., but on larger units tanks should never be used. The quantity of water in the tank is always small, and when the engine is loaded, it is not practicable to depend on radiation from the surface to keep the water cool. The choice then lies between a system of running water, allowing the water to go to waste, or a system comprising a cooling tower and a storage tank or reservoir.

When the water contains much mineral matter or sediment, it is best to use running water—depending, of course, on the cost of the water. If the installation is large, a water-treating plant might be installed to prevent the action of the bad water on the engine jacket. Usually, low-compression engine installations are too small to make such an investment profitable.

Some engineers have experimented with boiler compounds of various kinds, but with little or no success, because these compounds have no effect on the water until it is heated above 100 deg. F. Since the only place the cooling water reaches such a temperature is in the cylinder jacket, it is natural to expect the mineral matter to settle there.

It will, in most cases, be found advisable to use a cooling tower of some kind. When the engine is of 75 hp. or less, a tower such as that outlined in Fig. 1 is cheap to build, satisfactory in operation, and has a fair life. The cooling water is brought from the engine and discharged at a height sufficient to allow it to flow over the top of the tower. The tower supports a number of 1½-in. pipes branching from the main 3-in. discharge line, and each branch has a series of ½-in. holes drilled along its top surface. A rectangular sheet of wire netting is suspended from each pipe and the water issues from the holes in the pipe and runs down the vertical netting, being cooled to the temperature of the surrounding air before reaching the bottom. From the lower edges of the netting it falls into the storage tank, which may be either a cypress tank above the ground or a concrete reservoir. The use of the latter allows the tower to be lower and makes the discharge head from the cylinder less.

A type of tower that has found favor and that may be made of any required dimensions is shown in Fig. 2. The hot water from the engine jacket is discharged into the main trough *A*, from which it flows into the distributing troughs *B*. The distributing troughs extend laterally at right angles to the main trough and are perforated on both sides with rows of 1¼-in. holes *C* through which the water flows. The body of the tower contains a number of horizontal tiers of baffles *D*, which are staggered, so that the water falling from the distributing troughs is broken up into many sheets in its passage down through the tower. This subdivision of the water effects the necessary cooling by allowing intimate contact with the air.

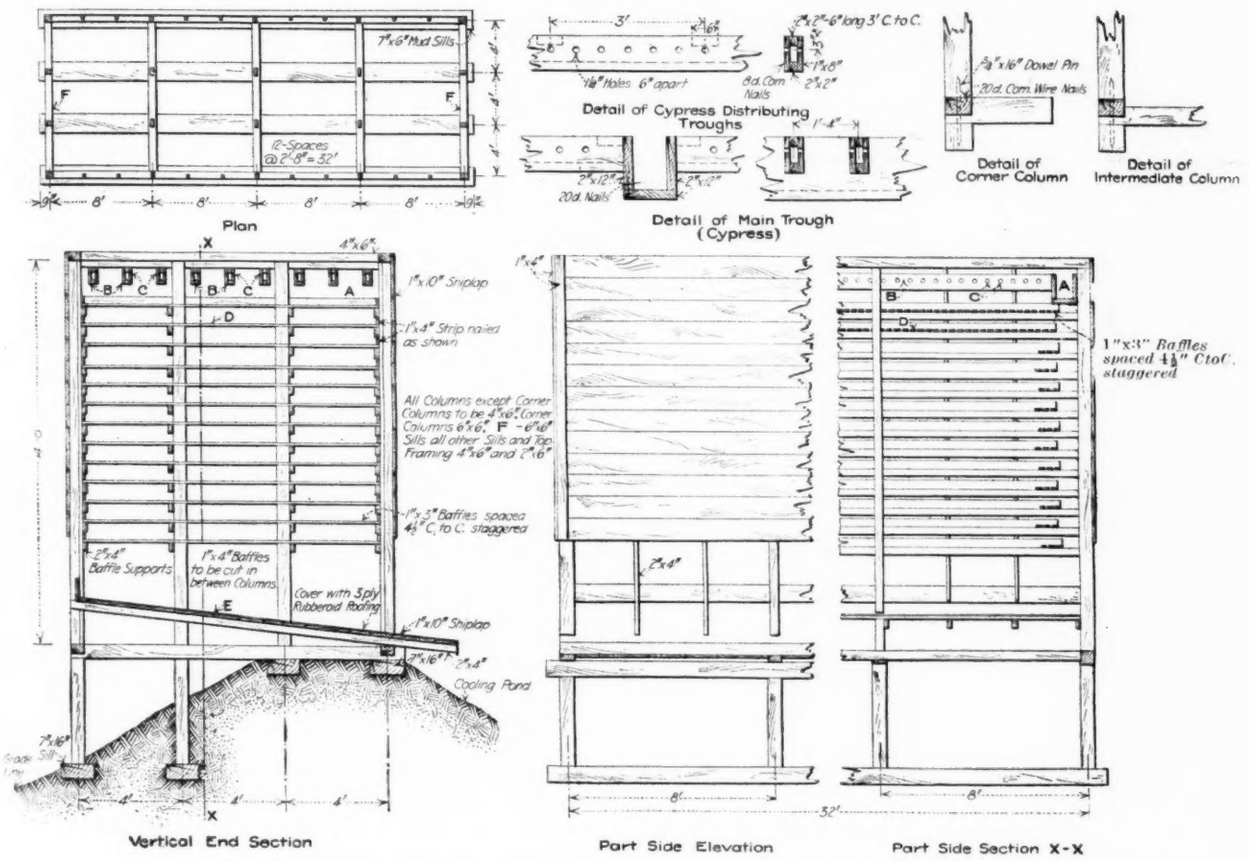

Plan
Detail of Cypress Distributing Troughs
Detail of Main Trough (Cypress)
Detail of Corner Column
Detail of Intermediate Column
Vertical End Section
Part Side Elevation
Part Side Section X-X
Cooling Pond
Cover with 3 ply Rubberoid Roofing
1"x3" Baffles spaced 4½" C. to C. staggered
1"x4" Baffles to be cut in between Columns
2"x4" Baffle Supports
All Columns except Corner Columns to be 4"x6" Corner Columns 6"x6" F - 6"x6" Sills all other Sills and Top Framing 4"x6" and 2"x6"
1"x4" Strip nailed as shown
1"x10" Shiplap
12-Spaces @ 2'-8" = 32'
7"x6" Mud Sills
16" Holes 6" apart
8d. Com. Nails
20d. Com. Wire Nails
20d. Nails

FIG. 2. WOODEN COOLING TOWER OF 500-HP. CAPACITY

At the bottom of the tower the water strikes the surface *E* and runs off into the pond. More commonly, however, the reservoir is placed directly beneath the tower. From the pond the water is pumped to an overhead tank, not shown, from which it flows by gravity to the engine. The advantage of this arrangement lies in allowing the water to be circulated some time after the engine is stopped, which will cool the piston and

prevent it from sticking. It has the further advantage of maintaining the circulation for a considerable period in case the pump stops due to accident.

Because of the danger due to pump failure, the overhead-tank system is by far the best. In case the first cost is considered too high to allow it to be used, the pump should be driven direct by the engine. The circulating pump should be driven from the engine shaft either by a link motion or by a chain. In no case should a belted pump be considered. Of course there are many belted outfits in use, but there is always danger that a belt will break or slip off. In one square mile there were three cases of broken cylinder heads due to interrupted circulation, caused by slipping of pump belt.

As to the type of pump best adapted to the oil engine, all types are to be found in this service. Owing to low first cost and few repairs, the centrifugal pump is much used, but it is not so good as some type of plunger pump or rotary pump. The centrifugal pump must be primed on starting. Frequently, the suction is temporarily stopped by leaves and the like. If extra care is not used, the pump may lose its suction and fail to keep up the circulation. In calculating the amount of water needed, general experience shows that 100 gal. per horsepower per hour is ample with the entering water at 70 deg. F. or lower. Provision should be made, however, for an excess of 50 per cent. over these figures.

Fuel Economy Made Simple

By A. BEMENT

Maintain a hot fire and control the rate of combustion by adjustment of the draft. No instruments or special knowledge required, the appearance of the fire being the one comprehensive guide to the fireman.

WHILE the subject of efficient combustion is one that has received the attention of engineers for many years, it is only since the stress of the present war condition has been upon us that the matter has generally been regarded as of vital importance, and in view of the impending crisis there is a desperate call for help. The fundamental difficulty is that the subject has presented itself as a complicated technical problem, involving gas analysis and temperature measurements, calling for, in most instances, an amount of technical skill and apparatus but seldom available. Present-day need is for very simple means, something that can be understood by the average person and requiring no instruments or special knowledge.

All problems, when fully understood, present themselves in quite simple terms, and the economical operation of fires is no exception to this rule. I would reduce the matter to two simple and readily understood requirements: (1) Always maintain a hot fire; (2) control the rate of combustion to meet the requirements for steam by adjustment of the draft.

When we examine what is implied by a hot fire, its significance is at once apparent. It is one of the laws of physics that heat flows from a hotter to a cooler body, and the rate of transfer is dependent on the difference of temperature of the two bodies. This means that if the heat is present at a high temperature, it will flow faster than if at a lower temperature. It is also true that the time available for transfer is an important factor. For illustration, a blacksmith may plunge a red-hot iron into water and remove it still red-hot if inserted and withdrawn quickly. If he keeps it in the water for a time, it will cool so it may be held in the hand. Thus, with time enough, heat may be transferred at a low temperature quite effectually. With a boiler, there is very little time. The gases that carry the heat pass through it in a fraction of a second. For this reason it is essential that the heat be at a high temperature. That there is a distinction between heat and temperature must be understood and realized.

In burning one pound of coal of 12,000 B.t.u., using in the process 15 lb. of air, there will be 16 lb. of gas to be heated by the pound of coal to a temperature of about 2500 deg. If, instead, 30 lb. of air is used, there will be 31 lb. of gas to heat. It is obvious that 12,000 B.t.u. will not heat 31 lb. of gas as hot as it will 16 lb., so instead of 2500 the temperature will be about 1250 deg. In one case there are 12,000 heat units at a temperature of 2500 deg. and in the other 12,000 heat units at a temperature of 1250 deg. Thus in one instance the motive power compelling the flow of heat to the boiler is twice as great as in the other. With these two conditions a gas analysis would show a higher CO_2 with the smaller air supply, likewise a measurement at the fire would show a higher temperature. Gas analysis and temperature measurements are things, for reason of simplicity, we wish to eliminate. Therefore, the fireman must depend on the appearance of the fire, which is not difficult, because almost anyone can recognize a hot fire when he sees it.

Operating a hot fire implies that fuel be added for the purpose of maintaining the fire in its uniform hot condition, instead of firing when steam pressure begins to fall. This is quite different from the usual practice, which is to fire in accordance with the demand for steam. The point to be made is that the fireman, in replenishing the fire, does so entirely regardless of the steam demand, with the object only of maintaining the hot furnace condition.

At this point the reader is liable to say that if such a program is attempted, so much steam will be made that the safety valves will be called upon to dispose of a large portion of it. But it is here that the second requirement, that of draft control, comes into operation. The rate of combustion—in other words, the speed at which the fire burns—is regulated by control of the draft; if more steam is wanted, the draft should be increased; if less, the draft should be decreased. In this way heat is always produced at a high temperature, but developed only as required.

For illustration a case last winter in a factory may

be cited where two boilers were employed for a moderate heating load at night. They were operated with full draft and burned 637 lb. of coal per hour. When one boiler was shut down and the load carried by the other, but still with full draft, the coal consumption dropped to 400 lb. per hour. Then a good hot fire was put under this same boiler, the breeching damper throttled down to a small opening, one of the ashpit doors closed and the other opened about 1½ in. at the edge. The draft was controlled by giving this door a greater or less opening, the same hot fire being maintained. The result of this operation was that the coal consumption for the same load dropped to 291 lb. per hour, and the labor of firing was much less. The load in this case was a small one, less than the capacity of one boiler. If it had been so large that the entire coal-burning capacity of one boiler had been required, then it would have been necessary to have used full draft. But with the light load, if a hot fire had been maintained with full draft, so much steam would have been made that most of it would have escaped by the safety valve.

The matter may be further illustrated by viewing it from the standpoint of the air supply. Usually the fuel is considered as the ingredient of first importance, but let us reverse it and consider the air supply as being of greatest significance. It is often said that a certain number of pounds of coal will produce a horsepower. Therefore, let us say that 50 lb. of air will produce one horsepower, provided of course that it is supplied with combustible. Air is 21 per cent. oxygen, and if the oxygen is saturated, so to speak, with combustible, the result is a high temperature. But suppose the need for steam is one horsepower, and 100 lb. of air is actually furnished. Now if so large an amount of air is satisfied with fuel, twice as much heat will be obtained as can be used. The usual result is that if the large air supply is continued, steam production is kept down partly by supplying less fuel and partly by wasting heat to the chimney.

Importance of Air Supply

It is apparent that the amount of air supplied to the furnace is of greatest importance, yet there is no visual evidence of the quantity flowing and the fireman can neither measure nor weigh it. He could ascertain indirectly by means of gas analysis or temperature measurement, but these are measures that cannot be resorted to if the problem is to be handled in a simple manner. It therefore follows that the appearance of the fire is the one comprehensive guide to the fireman. Any man can judge if he has a hot fire. It is an art resorted to by the operator of a variety of industrial fires in the metal and pottery trades, where the fireman satisfies exacting requirements, being guided by the appearance of the fire only. If the operator of such furnaces can secure the results he does by using his judgment, the boiler fireman should have no trouble with his much simpler problem.

One of the general difficulties that the fireman meets is the handicap due to the belief in certain fallacies and half truths. One of these is that because a strong draft is desirable under certain conditions, it is always a good thing, when in fact, it is harmful if it is not required. Unless the load on the boilers is equal to the strength of draft, it is harmful to the extent that it is in excess of requirements. The draft is the motive power which causes the air to flow through the furnace and the quantity flowing is in proportion to the strength of the draft. If the demand for steam is equal to all the air that can be supplied, then full draft is desirable and will produce a hot fire if the fuel is supplied. If the load, however, becomes less and the draft remains the same, it is necessary to supply less fuel, with the result that the fire is correspondingly cooler and the efficiency lower. A strong draft will produce better combustion than a weak one, and for this reason it is always desirable to use strong draft when possible. This points to the desirability of adjusting furnace capacity to match the load and leaving draft at the maximum. For example, it is better to reduce the number of boilers in use to the minimum, and use full draft than to reduce the draft and operate excessive capacity. In the case of one boiler, however, it would not be feasible to make much if any change in the furnace size, so the draft must be regulated according to load.

Condition of Fire, not Steam Pressure, Determines When Coal Should Be Added

The pressure according to the steam gage is usually looked upon as indicating when the fire should be replenished. If steam falls, the furnace is fired; if it is rising, coaling is withheld. This is wrong. Whether the steam is rising or falling has nothing to do with the time to fire. The fire should be replenished when necessary to maintain it in the uniform hot condition. So it is the condition of the fire that determines when coal should be added, not the steam pressure. In this way there is just as big a fire when a little steam is required as when working at maximum capacity, the difference being that at large capacity the fire is burned rapidly, while at small capacity it is burned slowly. If the fire is burning rapidly, it, of course, requires replenishing oftener than if burning slowly. If the steam falls, the damper should be given greater opening. If the steam rises, the damper should be given less opening. In the foregoing, the discussion refers more particularly to a condition represented by one boiler, but with a plant having a number of boilers it would be best to operate just enough at full capacity to carry the peak of load and regulate with the others.

The suggestions in this article will not find favor with many firemen until they have tried them. Some now feel that with hand-fired furnaces the coal should be "given a chance to burn," and by this is implied that the fire be allowed to burn low before replenishing. There seems to be a feeling that when this occurs there is evidence that the coal is well burned. Now if the purpose was to burn coal for the object of disposing of it, there might be something in this idea. The purpose, however, is to produce heat at a high temperature.

Boilers May Be Forced Without Damage

An opinion is quite prevalent that "it does not pay to force boilers." Quite a number of people feel that it is more desirable to operate at small capacity with low, or what has been designated as cold, fires than with good hot fires. This is a wrong assumption. No boilers are in general use today that cannot be heated to the full measure of their furnace capacity without difficulty or damage if they are kept clean inside.

There are few boiler plants that are provided with good dampers or damper control. Often dampers do not fit well enough to be effective, and more often they do not have convenient handles or means for their adjustment. The dampers should be made to fit if necessary, and be provided with a proper handling device. An effective scheme that the writer has used consists in bringing the damper control handle or rod to the front of the boiler at a position convenient to the fireman. Located in this rod is a plate having a sufficient number of holes drilled. These holes fit over a pin which is mounted stationary, so that any one of the holes may be placed over it. The hole at one end of the plate gives the damper full opening, the one at the other end full closure, and between there is a full range for any control needed. Every boiler should have its own damper.

Feed-Water Heaters in Ice Plants

By Victor J. Azbe

A feed-water heater in an ice plant, under certain conditions, may cause a greater loss than saving. This especially applies in plants making distilled-water ice only, but is true also in plants making part raw-water ice. A straight distilled-water ice plant is ordinarily short of water for making ice, and in many cases live steam is used to make up the shortage. The reason is that too cold water is used in the heater and therefore steam is taken from the exhaust line which otherwise would go to the steam condenser. It is important that feed water go to heater as warm as possible. Ordinarily, for every 10 deg. increase before reaching the heater there will be about 1 per cent. more distilled water available, which amount is large if we consider that otherwise it would have to be made up with live steam directly or indirectly by operating the plant more uneconomically to make up for the shortage of distilled water.

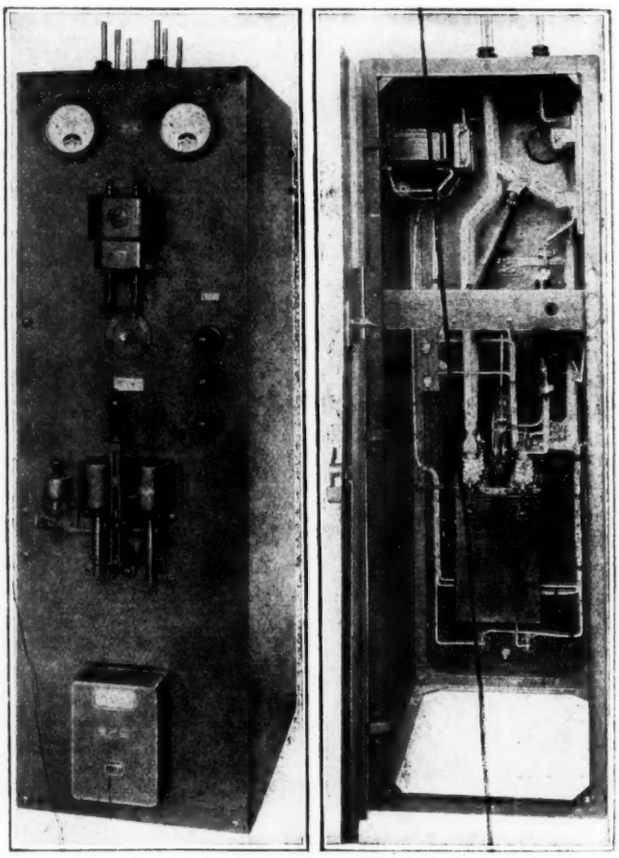
The selection of a heater for an ice plant is also important, and while, from one viewpoint, the closed heater would be preferable since the condensed steam would be available for ice making, on the other hand, with a closed heater much poorer ice will be made than with an open heater for the reason that the open heater acts as a reboiler, driving off the air and other gases which purge off through the vent. With closed heaters this air is bound to go through the heater into the boiler and engine. Under those conditions, of course, a greater amount of boiling is required in the reboiler, with resulting greater waste of steam. In some plants vacuum reboilers are found inadequate, and additional atmospheric reboiler capacity has to be used.

Feed-water heaters should be of such design that they do not separate the inorganic matter that precipitates during heating. Clogged feed lines and dirty boilers are proof of this contention. Proper filtering or settling equipment, would under the foregoing conditions, be of value and this even though some heat would be lost.

Steel Switching Cabinet

The steel switching cabinet, illustrated herewith and manufactured by the General Electric Co., is a unit made for single, quarter and three-phase circuits in capacities up to 300 amperes at 15,000 volts, and 800 amperes at 600 volts. All current-carrying parts are inclosed, and provision is made for bringing the leads out at the top, bottom or sides of the unit. The cabinet consists primarily of instrument transformers, oil circuit breakers and disconnecting switches inclosed in a sheet-steel compartment with instruments, operating levers, etc., mounted on the sheet-steel front.

The main switching apparatus consists of a standard switchboard-type oil circuit-breaker operated in the ordinary manner. The circuit-breaker is mechanically interlocked with the disconnecting switch so that this switch cannot be opened or closed while the circuit-breaker is closed. The disconnecting switch is operated by means of a special handle, or wrench, from the front of the panel, and is so interlocked that the rear door



SWITCHING CABINET IN CLOSED AND OPEN POSITIONS

cannot be opened while the switch is closed, nor can the switch be closed while the door is open. This makes it impossible for anyone to gain admittance to the compartment while the current-carrying parts are alive.

This apparatus has been designed for use as distribution and tying-in switches, as control switches for induction and synchronous motors, etc. It is usually mounted as a single unit, but may be installed in groups if desired. When made with a drip roof, the switching cabinet is particularly adapted to use in mines or other damp places. It can be made nearly water, gas and dust proof. It can also be used to control large motors in steel and cement mills, pumping plants, etc., where conditions often exist which cause switching apparatus to become damaged and put out of service, by dust, moisture and chains from traveling cranes.

Care of Heating and Ventilating Equipment—II

By HAROLD L. ALT

This article deals with boilers of the type used in heating work particularly, and contains many practical operating suggestions. Evaporation and capacity tests are urged, being the only means of ascertaining boiler performance.

ALTHOUGH there has been much written on the subject of boilers, there are a few points in regard to them that should be called to mind, particularly in relation to heating and ventilating work. Where high-pressure boilers are used for power-plant or other purposes and the exhaust- and reducing-valve connections are employed to supply the heating system, the boilers are not primarily used for heating and can hardly be considered as heating boilers. All the factors and stipulations applying to high-pressure power boilers are then applicable. For the purposes of this discussion "heating" boilers will be considered as low-pressure. In order to determine whether the boiler plant—and particularly the boiler portion—is strictly first-class in character it is a good idea to check as far as possible with the A. S. M. E. rules for boilers used exclusively for low pressure, up to 15 lb. gage. These rules are No. 335 to No. 377 inclusive.

Having a good boiler installation complying with the rules cited, the next point to be considered is capacity. This brings to the front the question of "rating," and, like the case of a power boiler, the rating of a heating boiler does not mean much. In steel boilers the usual rating is 10 sq.ft. of heating surface per horsepower, but in cast-iron boilers not even such value basis is considered in fixing the rating. In most cases manufacturers arbitrarily rate their product as capable of supplying so many square feet of radiation, sometimes on going so many hours without attention (coaling), sometimes on the burning of a certain number of pounds per hour per square foot of grate, and sometimes on no particular or consistent basis at all. Therefore with cast-iron boilers the rating is more often misleading than otherwise and will not be taken up in this discussion.

It is generally considered that eight to ten pounds of coal burned per hour per square foot of grate surface is pretty near the limit without forced or induced draft. If eight pounds is assumed to be a reasonable basis on large-sized units, then the capacity of a cast-iron boiler may be computed by the formula

$$C = 256\ G$$

when C is capacity in square feet of direct radiation or its equivalent, and G is the grate area in square feet.

This formula assumes that each pound of coal delivers 8000 B.t.u. to the water in the boiler and that each square foot of direct radiation gives off 250 B.t.u. per hour. Any other surface (mains, blast coils, etc.) must be reduced to the equivalent direct radiation by dividing the total B.t.u. which they require or give off by 250 and adding this to the direct radiation.

There is only one way to determine whether a boiler is really giving good service, and that is to test its economy and capacity. A rough estimate can be made, of course, by putting a meter on the water-feed line and weighing the coal, but if accuracy is desired a real, thorough test is the only way. For the purpose of standardizing test methods the A. S. H. V. E. recently adopted a set of standard rules that are undoubtedly the most suitable to use, as they were developed and arranged especially for low-pressure heating boilers, and they may be obtained from the American Society of Heating and Ventilating Engineers.

A boiler in good condition, clean and with proper draft, should evaporate in the neighborhood of eight to nine pounds of water per pound of good coal burned. With poor coal, of course such results will not be attainable, but the boiler efficiency should never fall below 60 per cent. The chimney draft may not be sufficient to give the capacity of eight pounds of coal per square foot of grate per hour (here again the original design enters in), but no great harm is done, even if the rate of combustion does not go up to this limit, as long as the pounds of water evaporated per pound of coal do not decrease. Lesser rates of combustion usually mean larger grates, longer periods between firings and a slight drop in the evaporation rate.

Operating Troubles with New Systems

With a new installation the operating engineer is quite likely to experience troubles of many kinds. "Mysterious" things are constantly developing, and faults of design seem to be the only cause. Some of these are: Water line fluctuates, water leaves the boiler, system becomes airbound in many places, water may fill radiators one or even two stories up, steam is not produced in sufficient quantities. The cause of all these ailments in most cases may be summed up in the one word—"oil!" Readers of *Power* are familiar with the danger from oil in high-pressure boilers, and it might be said that while the danger may not be as great in the low-pressure unit, the bad results are sufficiently magnified to make up for the difference.

In erecting a heating system every pipe thread is cut with oil, every radiator tapping is greased, and every boiler nipple is covered with a lubricant; as a result, when subjected to the action of steam and hot water, the oily matter is melted and carried back in the returns, most of it collecting in the boiler, where it forms a film over the surface of the water, coats the inside boiler surfaces including the gage-glass and, if air valves are used on the system, clogs up the tiny outlets and causes air binding. Some heating engineers claim that oil alone causes no trouble in a low-pressure heating boiler and that it is only when oil unites with alkaline impurities in the boiler so as to form a soapy mixture that trouble ensues. Be this as it may, the alkaline substance is usually there and when the oil arrives there is trouble. It is generally conceded that the effect of oil in a boiler is to interfere with the transmission of heat from the tubes or heating surface to the water and to prevent the free separation of steam rising from the water due to the film of oil over its surface. This results in priming or foaming, water leaving the boiler by

way of the steam main whenever it is fired hard. Most operating engineers who have undertaken to operate new plants have found out the wisdom of running the returns directly to the sewer for the first month or so, such treatment resulting in a thorough washing out of

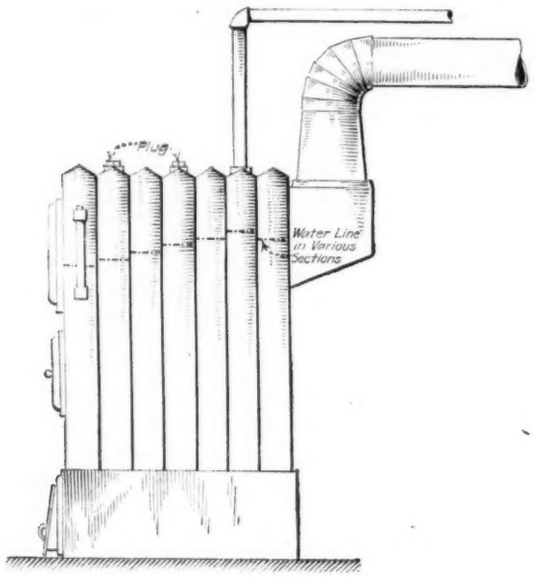


FIG. 1. VARIATION IN WATER-LEVEL WITH ONE STEAM OUTLET

the system and getting rid of a large amount of pipe scale, radiator core sand, dirt and stones, which may have found their way into the pipe. Wasting returns for a while is a procedure that should be followed in every new plant and the length of time is dependent on how long trouble is experienced with oil. One old engineer says six months, another says sixty days; but it is purely a matter of "as long as necessary." This, however, will not help out the automatic air valves which become clogged by oily steam. Such trouble may be overcome in one of two ways—first, by using old or temporary air valves for the first month or two and then replacing these with the permanent valves; second, by washing out any valves so clogged, with benzine or kerosene, which will dissolve the grease, or by boiling them in a solution of washing soda and water, the soda cutting the grease and forming a soapy mixture that is easily dissolved in water. Oil already in the boiler cannot, of course, be driven out by wasting the returns; it is only possible to get rid of it by continued and persistent effort. Blow off, drain out, boil out, use a surface blowoff when possible, and repeat until cured. For the ordinary blowing-off all that is necessary is to open the drain cock with about five pounds of steam pressure in the boiler and blow down a gage or two of water. This clears out the sediment, loose scale and any other loose material that has fallen to the bottom of the boiler. Such procedure, however, will not take care of impurities that may be dissolved in the water, floating on its surface or attached to the inner surfaces of the boiler.

The remedy for a greasy or oily boiler is a good boiling out with common washing soda. The best method is to allow the steam pressure to go down, remove the gage siphon or safety valve, pour about five pounds of soda dissolved in a gallon of water through a funnel into the boiler, raise and maintain about five pounds of steam pressure for an hour, then draw the fire and drain the boiler while still hot. Allow the boiler to cool, refill with cold water and drain a second time, then refill and start a new fire. The action of the soda inside of the boiler when combined with heat is the same as explained for the air valves—a soapy mixture is formed which may be carried away with the water. Another method of cleaning might be called a "surface blowoff" and is similar to that used for clearing high-pressure boilers of oil. This consists of the application of soda as described, but a pipe is connected to an opening at the top of the boiler, probably the safety valve tapping, and is piped outside the building or to a tub of cold water with an overflow. The boiler is then fired awhile without making any pressure, and then the water line is gradually raised by adding feed water until the surface water overflows through the temporary pipe, thus positively getting rid of the surface scum. After this the boiler is emptied and refilled ready for service. The advantage claimed for the surface blowoff is that it cleans off the surface of the boiler, while if the boiler is only drained after boiling, the water, in running out, deposits a large part of its scum on the interior surfaces as it falls, making this method less effectual.

Another cause of trouble in heating boilers is the practice indulged in by some steamfitters of connecting up only one boiler outlet, as shown in Fig. 1, when two or three outlets are provided. Now there is a good and definite object in providing several steam outlets, and this is to keep the velocity of the steam down to a reasonably low limit and to prevent too much difference in pressure on the surface of the water. It must be remembered that low-pressure boilers are without dry

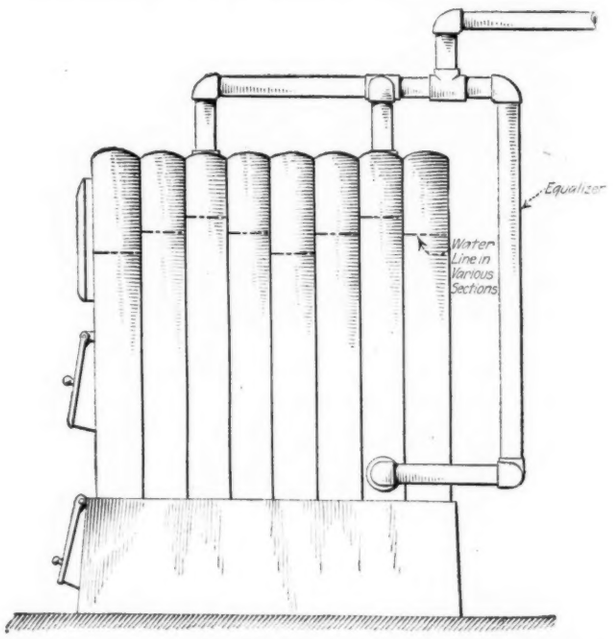


FIG. 2. TWO STEAM OUTLETS AND AN EQUALIZER PIPE

pipes and baffles, so that the only means of getting good dry steam is to make its velocity low enough so that no entrained water will be carried over. When making steam, a boiler with only one outlet will have its water surface appear somewhat as shown in Fig. 1, while if two outlets are provided the effect is as shown in Fig.

2. Thus it can be seen that the tendency for the water to carry up into the main is much less with two outlets. The raising of the water under the outlet is due to the slight decrease in the steam pressure at this point. This may also affect the level shown in the gage-glass, for when placed at a point farthest from the steam outlet, the gage water level will be lower, while

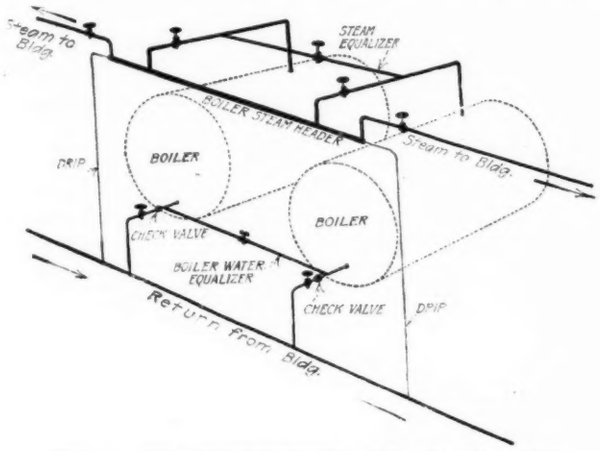


FIG. 3. PIPE CONNECTIONS FOR TWO OR MORE HEATING BOILERS

if placed close to the steam outlet the water level indicated will be much higher than the mean water line. Many heating men advocate the use of a balance or equalizing pipe in gravity heating systems, consisting of a large pipe connection betwen the steam and return mains at a point close to the boiler, as shown in Fig. 2. The claim is made that a more stable water line is maintained in the boiler, but the writer does not place much faith in these claims. The cold-water feed line connected directly to the boiler should be provided with a check valve, so that any failure of water pressure at the time the boiler is being filled will not allow the steam pressure to blow the water back into the water main and empty the boiler.

The operation of a single heating boiler involves no great technical knowledge, as is evidenced by the ordinary domestic installations, many of which are operated by the housewife or servant. When they are increased in size or with two or more boilers, their operation, valving and piping become more complex. The use of an equalizing pipe between two or more low-pressure boilers does no harm, but whether it does good is doubtful. Certainly, high-pressure boilers require no such treatment, and it has never been quite plain to the writer just why equalization cannot and will not be secured through the steam main if of proper size. One case in particular proved that even the equalizing pipe failed to equalize. There were three horizontal return-tubular boilers connected by ample steam and return connections to a common steam and return main. In addition there was provided an equalizer pipe connected to each boiler, of the same size as the steam connection. There were no check valves in the return lines to the boilers, so that conditions seemed such that unequal water levels would be impossible. Yet when all three boilers were in operation, it was impossible to maintain the water level even. Trouble occurred every time one of the boilers was fired; the water level in the one coaled would immediately start to rise and would continue to go up for two or three minutes until it had gone out of sight in the gage-glass, with the water in the other two boilers correspondingly lowered. Firing the boilers in which the water was low immediately pulled the water back into them from the first boiler. This effect could be produced, in fact could not be prevented, in any of the boilers, the one with the hottest fire having the lowest water line. The trouble was remedied by putting check valves in the return connections of the individual boilers similar to those which are indicated in the battery of two boilers as shown in Fig. 3, and without any alteration in the steam or equalizer pipes. A single low-pressure boiler can be run without a check, although some prefer to use them in all cases.

One of the common difficulties encountered in operating a low-pressure plant is to determine where the water line really is in the boiler. Many a scare has resulted from the water apparently leaving the boiler, as shown by its dropping out of the gage-glass and try-cocks; in fact, the whole apparatus will, under certain conditions, lie in a shocking manner, but it is easily caught if you know how. This trouble is usually caused by connecting the lower end of the water column into the boiler at too low a point, as shown in Fig. 4, and as a result when the water starts to boil or form steam bubbles (just before getting up steam) and also when steaming at an excessive rate (fire forced) the boiler water becomes filled with minute globules of steam which occupy a certain proportion of the water space and thereby reduce its weight. The water in the water column and its low connection into the boiler does not become heated to the same extent and therefore retains all its original weight, weighs more per foot of height than the boiler water, and to establish an equilibrium the cooler water sinks until the two weights counter-

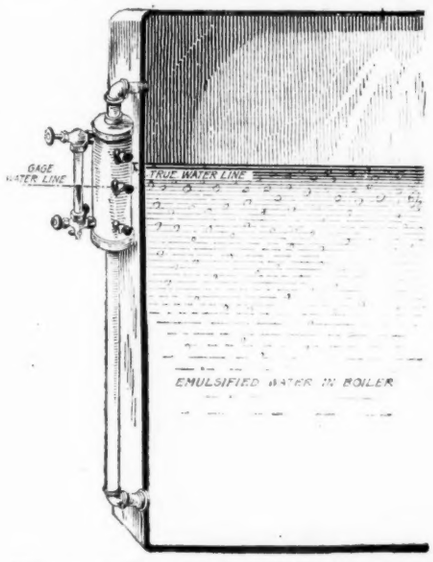


FIG. 4. MISLEADING WATER-LEVEL INDICATION

balance, but in the meantime according to the gage-glass and try-cocks the water has left the boiler and things are considered to be in a dangerous condition.

To test whether the water has really left the boiler, shut the supply and return valves, bank the fire and wait until the water cools down. If the water comes back into the glass when both steam and return valves are closed, it proves conclusively that it wasn't out in the

piping and therefore was in the boiler all the time. On the other hand, if the water does not come back, it proves that it does leave the boiler and conditions should be remedied at once. Most of this false information can be prevented by connecting the pipe from the bottom of the water column into the boiler at a level not to exceed six inches below the bottom of the water column. When so connected, although the difference in the weight of the water in the column pipe and boiler remains as before, the height is so much less that the difference in level is small.

In placing check valves in the return lines to a boiler, there is often much argument as to which side of the stop valve the checks should be located. If there is only one boiler, it is advisable to have the check valve on the house side of the stop valve, for in this case the boiler can be kept in commission while the return from the house is shut off and drained while repairs are made to the check. But with two or more boilers the check should be located on the boiler side, between the stop valve and the boiler, so that the heating system and one boiler can be kept in operation while the other boiler is drained out and the check repaired. Of course the best way is to place a stop valve on each side of the check valve, but in low-pressure work this is seldom done. The most approved method of connecting up a battery of heating boilers is shown in Fig. 3.

One thing the engineer should keep in mind in regard to forcing: It has been conclusively proved in tests that a greater evaporation rate can be obtained at a high rate of combustion than at a low rate, so that with the maximum draft and the fire as hot as it can be made, more pounds of water will be evaporated per pound of fuel than when only a moderate rate of combustion, say five or six pounds of coal per square foot of grate per hour, is maintained.

Throttling of Ammonia

By CHARLES H. HERTER

Engineers sometimes inquire whether during a shortage of ammonia any disadvantage might result if, instead of regulating several expansion valves singly, the main liquid valve (also known as king valve) at the liquid receiver were throttled down so as to obtain at once the desired reduced feed of liquid to the refrigerating coils. The article answers this question.

THIS simplified method of operation is sometimes used where one or more expansion valves are located at an inconvenient distance, an intermediate valve being placed at some easily accessible point in the liquid feed line. The expansion valves are then set for full normal feed and the intermediate valve is used for coarse regulation and for shutting off altogether. If, instead of this intermediate feed valve, the main liquid stop valve is worked as a pressure-reducing valve, and left but one-eighth of a turn open, the resulting wire-drawing will subject the soft-seated valve to excessive wear and it will soon leak. Under this condition the suction pressure and condenser pressure will equalize after the machine is shut down, and after starting it may take a long time to pump the suction pressure down, unless all expansion valves are or can be closed tight. In other words, the main liquid valve should either be kept full open during running or be closed altogether when machine is stopped, and an intermediate expansion valve or cock should be used if individual throttling of the regular expansion valves is to be avoided. In fact the latter method may be found convenient where mistakes of unskilled operators are to be guarded against, because the careless flooding of any one coil might send excess liquid to the compressor and knock out a cylinder head, with the usual disastrous result.

A further advantage of the intermediate or supplementary liquid valve in the engine room or other accessible place lies in the ability to shut off promptly the liquid in case of fire or other emergency where it may be dangerous to run up to the roof to close the main liquid valve at the liquid receiver. Liquid valves should be distinctly labeled.

There is still another side to this question of feeding ammonia in stages. With normal operation the entire pressure reduction from condenser to evaporator pressure is effected at the final feed or expansion valves. We learn from thermodynamics that in a throttling process of this kind the total heat content per pound of fluid in circulation remains unchanged except for the insignificant loss of heat due to the kinetic energy of the liquid flowing from the higher to the lower pressure. To check this item, we refer to Goodenough and Mosher's Ammonia Tables (1913) and note that the volume of 1 lb. liquid at 0 deg. F. = 0.02437 cu.ft., which after throttling from 200 lb. absolute, gives $\frac{144}{778} \times 200 \times 0.02437 = 0.89$ B.t.u. Even if based on 95 deg. F. liquid, this loss amounts to but $\frac{144}{778} \times 200 \times 0.02734 = 0.999$ B.t.u. per lb. and is therefore regularly neglected, especially as the properties of ammonia are not known to this degree of precision.

From the ammonia tables it is apparent that as the pressure is lowered the saturation temperature is lowered automatically. The latent heat of vaporization of a portion of the liquid is employed to cool all the ammonia from the temperature of liquid, such as 96 deg. F. down to the temperature of the refrigerant which may be 0 deg. F. This work represents a loss of 18.5 per cent., because at 30 lb. absolute pressure (0 deg. F.) the heat of vaporization is 572.2 B.t.u. per lb., from which deduct the difference in heat content of liquid at 96 deg. F. (200.5 lb. absolute) and 0 deg. F., which is 72.5 — (— 33.7) = 106.2, leaving net 466 B.t.u. available for useful refrigerating effect. Incidentally, this shows that in this case, assuming complete evaporation of all liquid, 199.2 ÷ 466 = 0.4275 lb. of ammonia must be circulated through the system per minute per ton of refrigeration.

The vapor resulting from but 0.1 lb. occupies at 100 lb. absolute pressure a space of 0.2938 cu.ft., while the 0.9 lb. of liquid at the same pressure takes a volume of 0.0233 cu.ft. Evidently, the vapor requires in this case 12.6 times the space of the liquid, and as this extra volume is not available the intermediate pressure cannot be much below condenser pressure, otherwise the rate of flow of liquid and vapor through the final expansion valve would be so much increased as to accelerate also the wear at this point.

Expansion Cylinder and Over-all Efficiency

Occasionally, the old suggestion is repeated; that is, utilize the energy available when the high-pressure liquid is allowed to drop to the low pressure of the refrigerator, by letting the resulting vapor work against the piston of an expansion cylinder. Reference to the entropy diagram shows that with the conditions stated the net refrigerating effect would increase to 476.5 B.t.u. per lb., so that only $199.2 \div 478.5 = 0.416$ lb. of ammonia would have to be pumped per minute per ton. But this gain of 2.6 per cent. would be diminished by friction and is not sufficient to offset the extra cost and complication involved. Nor is it correct to assume that the throttling of the main or intermediate liquid valve is equivalent in effect to the work of a regular expansion cylinder. It is not because space is unavailable at the high-pressure side of the regular expansion valves to accommodate the resulting vapor. By the use of analytical calculations a gain of 2 or 3 B.t.u. per lb. may still be discernible, but so long as such devices as liquid precoolers and liquid separators that offer positive economies of 5 to 15 per cent. are not more freely employed, it is useless to strain after an uncertain gain of one-quarter of one per cent. by throttling and wiredrawing. If more attention were paid to reducing friction in the ammonia system by means of proper-sized lines and fittings or larger radii, a further saving in power could be effected with certainty, while the expansion cylinder has never been proved to raise the over-all efficiency.

From the foregoing the conclusion seems justified that intermediate throttling of liquid is entirely proper under certain conditions. The only harm that can result is in more rapid wear of the valves used. From a thermodynamic viewpoint no noticeable benefit is obtained by reducing the pressure upon the liquid gradually instead of all at once as in the regular expansion valve. The inserting of an emergency feed valve supplementing the main liquid valve, and ordinarily left full open, is considered good practice. To simplify the regulating of a number of feed valves by preventing their periodic choking with scale and impurities, a suitable strainer which can be bypassed and cleaned out should be inserted in the liquid line.

Setting the Valves on Duplex Steam Pumps

By P. R. Prescott

When the standard method of setting the valves on a duplex steam pump of the direct-acting type is used, the pistons are first pushed to the end of the stroke and marks are made on the piston rods at the packing-box gland. Then the pistons are moved until just beyond the center of the stroke, when a second set of marks are laid off on the rods by measurement from the first marks, the distance being exactly equal to one-half the piston stroke. Then if the pistons are pushed back until these latter marks are in line with the packing-box gland, it is obvious that the pistons are at midstroke, and if the valves are centered over the ports in the steam chest and the lost motion in the valve gear is equalized, the valves will be correctly set.

If the pump is new, the lost motion in the valve gear may be equalized, as it consists only of that left by manufacturers for the proper operation of the valves. However, on most pumps that have been in service for any great length of time, lost motion may be found in the rockshaft bearings, in the various valve-gear links, and even where the valve-gear lever connects with the spool on the piston rod there will be some wear.

To equalize the lost motion on a used pump by the standard method becomes rather difficult. It is like trying to adjust the lead on an old Corliss engine by moving the engine past the center and then moving it backward until the center mark is reached.

There is, however, a simple method for accurately setting the valves on such pumps. Although this method is not new, I have never seen it in print. It is quicker than the standard method on a new pump and furthermore it is accurate on any pump, however badly worn it may be.

First push one of the pistons to either end of its stroke then note if the slide valve on the opposite side has fully uncovered the steam port; if the port is not wide open, or if the valve has overtraveled, note the amount and push the piston to the end of its stroke in the opposite direction. The valve then should have fully uncovered the other steam port. If the valve does not open an equal amount on each end, the valve stem should be adjusted, if lost motion is inside the steam chest; or if outside, the tappets should be so adjusted that the steam valve opens the port the same amount when the piston is at either end of its stroke. The other valve is set in the same manner.

If the valves do not fully uncover the steam ports, or very nearly so, it will be on account of the wear on the valve gear, and the remedy is to decrease the amount of lost motion allowed by the manufacturers, in order that the valve may have full travel. If the lost motion is inside, a washer may be put on the valve stem or a liner may be riveted to the block which moves the valves; if outside the tappets may be adjusted to give the valves full travel.

It will often be found that an old pump may be made to operate like a new one by setting the valves in the manner described, simply because the steam valves will have the proper travel, regardless of the wear on the valve gear.

The Liberty Loan committee has adopted the suggestion of Thomas A. Edison that every letter written in the United States during the next five weeks shall close with the words, "Yours for the Fourth Liberty Loan." The postoffice department estimates, if the suggestion is followed, the slogan will be written more than 40,000,000 times every 24 hours.

Yarway Blowoff Meter

In the majority of boiler plants there is no means for the engineer to determine when or how often the boilers are blown down or of indicating the period the blowoff valve is open. Some engineers have realized the importance of checking the firemen and have placed home-made devices of one kind or another on the blowoff pipe so as to register when the fireman blew down the boiler. These devices were naturally crude, but their value is apparent. Recently, the Yarnall-Waring Co.,

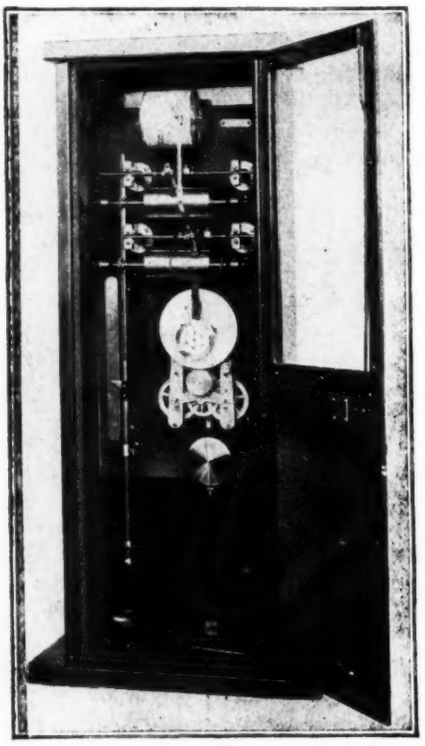


FIG. 1. YARWAY BLOWOFF METER

Chestnut Hill, Philadelphia, designed a special Yarway blowoff meter for the Philadelphia Electric Co.

The meter, Fig. 1, prepares a chart as shown in Fig. 2, on which appear two separate records, one of which is written with a short pen (see line *A*) and which is magnified ten times. In other words, the range of the short pen is 0 to 33,000 lb. per hour, and that of the long pen is from 0 to 300,000 lb. per hour, as shown by the marginal figures on the chart. The idea is that small leaks through closed blowoff valves are hard to see on a record made on a scale sufficiently small to take in the violent peaks in the curve at the time when blowing down takes place. On such a chart leaks are barely noticeable by a slight lift of the curve off the zero line. The object of the second pen is to show a decided peak in the curve for such a leak. This is shown by the curve *A* where it is marked "leak" on the upper line at the right of Fig. 2.

The upper cam drum, which provides the magnified reading, has a number of almost parallel grooves at the upper end to hold the pen in a top position at such time as the meter indicates more than 30,000 lb. per hour. Different-colored inks are used on the two pens, and colliding is prevented by spacing the pens two hours apart. An examination of the chart shows that there are two sets of figures at the bottom, the upper one being in black and the lower in red ink and indicated by

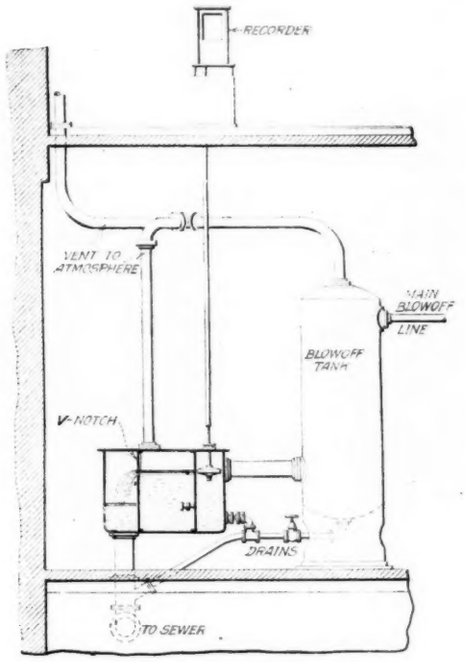


FIG. 3. ARRANGEMENT OF METER AND RECORDER

roman and italics respectively. The corresponding chart lines are shown at *B* and *A*. Fig. 3 shows the general arrangement of the meter in the basement with the recorder on the floor above. By this arrangement the meter proper is placed convenient to blowoff tank and the recorder can be placed where it can be readily read.

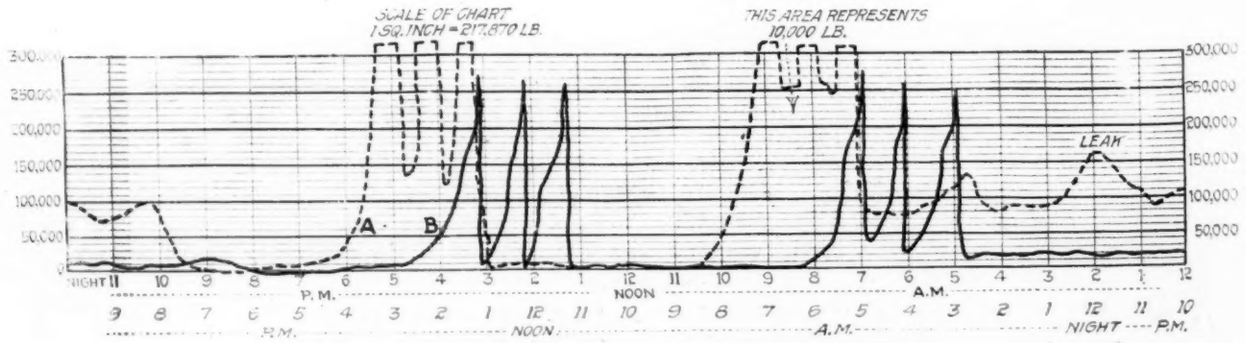


FIG. 2. CHART MADE BY THE YARWAY BLOWOFF METER

Additional Power by Using Low-Pressure Turbine

Electric-motor drive, the simplest solution to additional power-supply problems, is oftentimes not available in mill plants driven by lineshafts. Often, however, there is sufficient boiler capacity in the plant to do the work, if it is effectively applied, particularly where lineshaft drive to a small number of machines is used. The installation of a turbine with speed-reducing gears is an ingenious solution to the problem.

A UNIQUE lineshaft drive, consisting of a Westinghouse low-pressure turbine and a Westinghouse double-reduction gear, as shown in Fig. 1, has been installed in a western Pennsylvania paper mill. There are two main lineshafts to which the machines are belted. To one of the lineshafts are belted two cutters, ten beaters and one Jordan, and an identical equipment, with the exception of the cutters, is belted to the other shaft. Only seven of the ten beaters, under ordinary running condition, are in operation at one time, and these, with one Jordan, require about 600 hp. An additional 20 hp. is needed for the rag cutters.

Heretofore, each of the two lineshafts was driven by a noncondensing reciprocating engine, but one of the engines was wrecked and a drive was required to replace it, at the least ultimate expense. It is interesting to note the considerations entering into the final selection of the new drive: Two 100-hp. noncondensing engines turned the rolls and gave practically all the exhaust steam necessary for feed-water heating, so that all the exhaust steam from the 700-hp. noncondensing Corliss engine driving one of the lineshafts would have to be discharged to the atmosphere unless some means were provided for abstracting the energy still available in it. A low-pressure turbine was the logical prime mover, but it would have been of little use on account of its high speed, had there not been a reduction gear to receive the power generated and to deliver it to the lineshaft at low speed.

A few approximate figures show more clearly the fitness of the low-pressure turbine for this application. The exhaust steam from the 700-hp. Corliss engine was more than sufficient to give 600 hp. in the low-pressure turbine. The engine takes steam at 150 lb. pressure and exhausts into an oil separator at a back pressure, depending on the load, of from 0 to 4 or 6 lb., which is approximately the pressure of admission to the low-pressure turbine. The steam is then expanded in the turbine down to a vacuum corresponding to 27½ in. of mercury referred to a 30-in. barometer, the vacuum

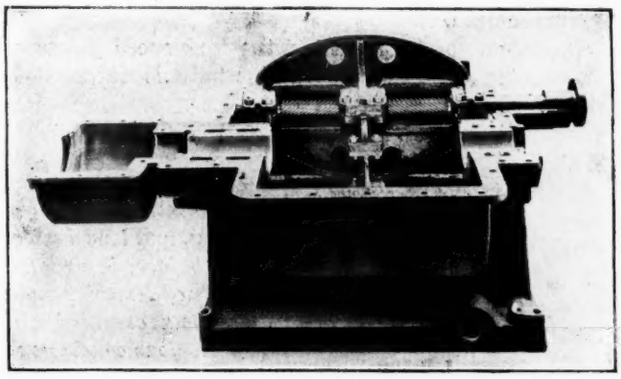


FIG. 2. SHOWS I-BEAM SUPPORT FOR THE FRAME OF THE PINION BEARINGS

being maintained by a Westinghouse-Le Blanc low-level jet condenser and air pump. The pumps are centrifugal and are driven by a small turbine through a reduction gear. They take their water from a near-by creek and discharge it from the condenser into a reservoir at an elevation of 45 ft., which water is used in the manufacturing processes. The small turbine runs noncondensing, and its exhaust steam goes to the feed-water heater, so that only a part of the heat energy in the steam used by it can be charged to the turbine, and even that cannot be charged against the main turbine, for it is used to do work in elevating the discharge water from the condenser to the reservoir and should be charged against the total cost of manu-

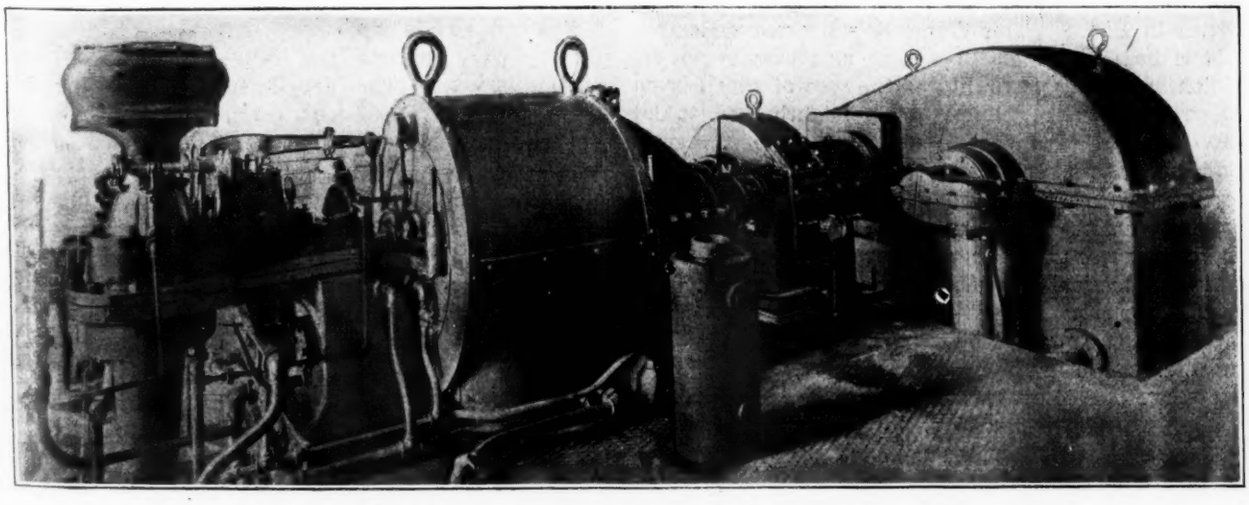


FIG. 1. VIEW OF LOW-PRESSURE TURBINE WITH REDUCTION GEARING AT THE RIGHT

facturing. In brief, it may be said that this paper company actually gets 600 hp. without paying a cent for steam, and that it is using just one-half the steam formerly used with two reciprocating engines to obtain the same power.

While this particular mill was not enlarged, it is evident that with a given amount of exhaust steam, from either noncondensing engines or condensing engines run noncondensing, a large increase of power is made available by the installation of a low-pressure turbine. Further evidence of this possibility for expansion is the fact that in this paper mill when the two lineshafts were driven by noncondensing reciprocating engines, a battery of 13 boilers was required, whereas, now only eight boilers are required for the maximum load.

The means of transmitting the high-speed power of the turbine to a slow-speed lineshaft is interesting. The change in speed is made by means of two reduction gears because the first cost of a single gear and pinion of ratio 36 to 1 would be prohibitive, and the gear would be very large and unwieldy. The first speed reduction, 3600 to 720 r.p.m., is made with a fixed-bearing type of reduction gear, the gear shaft of which is direct-connected to the pinion shaft of the second gear, which reduces the speed from 720 to 103 revolutions per minute. This larger reduction gear is of the flexible pinion-frame type, better known as the Westinghouse I-beam type. It is this I-beam feature which makes the application of the geared drive possible. In this, the pinion is supported on three bearings in a frame, as shown in Fig. 2. This frame is supported under the middle bearing on an I-beam at right angles to the pinion axle. The flexibility of the web of this I-beam support allows the pinion to tip slightly and to let the teeth of the pinion line up with those of the gear. This lining up is entirely automatic and instantaneous in operation, so that no mechanical complications are encountered, and no adjustments from the outside of the gear case are necessary at any time.

Both reduction gears are lubricated by sprays of oil directed upon the teeth just before they mesh. The pressure is maintained by a pump geared to the gear shaft, as shown in Fig. 1. This pump also supplies oil under pressure to all the bearings in the two reduction gears. For starting, a hand pump is provided which insures a plentiful supply of oil on the bearings and teeth.

It may be asked why a fixed-bearing type of reduction gear was used in one case and an I-beam in the other. It was a question of tooth pressure which determined the design. Take, for instance, a pinion transmitting 600 hp. at 3600 r.p.m., which was the case of the first reduction gear in the particular installation under discussion. If the same pinion were to turn at 720 r.p.m. and with the same pressure per inch of tooth face, it would be capable of transmitting one-fifth of 600 hp., or 120 hp. only. It follows, then, that the second gear would have been made five times as large as the first if the same type had been used, and for the transmission of the same amount of power. Such reduction gear would have been large, bulky and costly.

The Westinghouse I-beam support for the pinion corrects any misalignment and uneven pressure distribution that might otherwise exist. Misalignment might have been due to temperature changes, slight but unavoidable inaccuracies in workmanship, or distortion of the bearing supports in the housing, due to varying loads or changes in foundations, and if not corrected, would have caused the total tooth pressure to be concentrated at one part of the tooth, which would have overstressed that part of the tooth and have caused it to fail. In the case of the reduction gear with fixed bearing support for the pinion, misalignment, although practically prevented by good workmanship, will not have disastrous results if it should exist, because of the high factor of safety used in the tooth design. In other words, localization of total tooth pressure would not stress the metal beyond a safe limit. The self-aligning feature, the forced lubrication, the rugged construction of the parts, and the workmanship on these reduction gears make them a very efficient and reliable means of transmitting power. The actual efficiency of the two gears together is 97 per cent., showing that only 3 per cent. of the total power transmitted is lost in them. This energy is dissipated in the form of heat, and is taken up by the oil. As to reliability, in the paper mill under discussion the double-reduction gear has run 24 hours per day, six days per week, under maximum load, and it has never been shut down on account of trouble with the gears.

Again the Government comes to the people of the country with the request that they lend their money, and lend it upon a more liberal scale than ever before, in order that the great war for the rights of America and the liberation of the world may be prosecuted with ever increasing vigor to a victorious conclusion.

And it makes the appeal with the greatest confidence, because it knows that every day it is becoming clearer and clearer to thinking men throughout the Nation that the winning of the war is an essential investment. The money that is held back now will be of little use or value if the war is not won and the selfish masters of Germany are permitted to dictate what America may and may not do.

Men in America, besides, have from the first until now dedicated both their lives and their fortunes to the vindication and maintenance of the great principles and objects for which our Government was set up. They will not fail now to show the world for what their wealth was intended.—Woodrow Wilson.

The only means by which our armies can be maintained and equipped in the present crisis are offered by the Fourth Liberty Loan. The only way the complete success of the Loan can be assured is by the hearty support of the entire American people.

The "Fighting Loan" must win.

EDITORIALS

A Time for Extreme Caution

ON other pages of this issue is described the wreck of an engine flywheel and the damage caused by this failure. The probable cause of this accident is stated in the article and there is no need of considering it here. It is the fact that a serious accident occurred, one crippling a large plant, that excites comment. This is aggravated by other recent and serious accidents to large prime movers.

Power-plant men must always be cautious; but this is a time for extreme caution against any condition that may tend to make equipment fail to deliver power or to function. The War Industries Board is concerned about the shortage of power. The situation is serious. The emergency bill now before Congress will, if passed, make two hundred million dollars available for power plants, but the need for equipment is extraordinarily urgent; it cannot be conjured even with money. The War Industries Board has been commandeering engines, turbines and electrical equipment and turning them over to industries engaged in urgent war work. To meet the exigencies by development of new water-power projects is impossible; time does not permit of it. Many districts are woefully short of power, among which are Philadelphia, Pittsburgh, Massillon, Charleston and other parts of the South, also the East.

Every accident that puts turbines, engines, boilers, any power-plant machinery, out of commission increases the gravity of the situation. Guard against them; inspection and vigilance were never more necessary. Every man about the plant should be made to understand the real situation—that he may not contribute to accidents by indifference and neglect.

Saving Money in the Boiler Room

ACCORDING to a statement issued by New York State Fuel Administrator Cooke, owners of 237 boiler plants in the nine southern counties of New York State, which include Greater New York, have already replied to the questionnaire sent out by the State Fuel Administration. Among the replies are twenty-one, covering steam plants that consumed 628,315 tons of coal last year, the owners of which advise the Fuel Administrator that the improvements and repairs they are making will save 68,023 tons of coal a year, or eleven per cent. of their last year's consumption. The estimated shortage of coal is less than eleven per cent., and if other consumers can effect similar economies the supply will be adequate, provided labor troubles do not suspend operation at the mines.

From the foregoing it is evident that the owners of boiler plants in the territory mentioned are coöperating with the State Fuel Administration in conserving fuel by making improvements and repairs in their plants. The strange feature of the situation is that these plant owners did not take steps long ago to prevent this eleven per cent. waste. Probably one reason is that they did not know that such a saving was possible. There are thousands of plants burning on the average of four tons of coal per day, and with three hundred working days there would, with an eleven per cent. decrease in consumption, be a total of one hundred and thirty-two tons of coal saved per year, which, at seven dollars per ton, would make the yearly saving of over nine hundred dollars—a tidy profit indeed and one that is being thrown away in many plants every year.

The reasons why fuel is wasted in steam plants are two—either the engineer in charge is not competent to manage the plant economically, or he cannot obtain the necessary instruments to enable him to properly determine what results are being produced.

Most small steam plants could take a leaf from the practice of the larger, modern ones to advantage. In these latter practically every kind of apparatus is supplied the engineer so that he can obtain records that give him data on which to figure the performance of his plant as a whole.

If some of the smaller plants have a correct steam gage and a properly operated safety valve, they are fortunate. When it comes to CO_2 apparatus, temperature-recording gages and steam-flow meter, etc., these are appliances which the owner does not believe to be necessary or does not take enough interest in to see that they are installed.

If under the instigation of the State Fuel Board twenty-one steam boiler plants will make a saving of eleven per cent. in fuel consumption, it is difficult to understand why all the remaining boiler plants cannot do as well, and many of them better. Why an owner of a steam plant refuses to save coal when it puts money into his pocket, until he is forced to do so by the Fuel Administration, is beyond comprehension.

The ground may be taken that the plants that are expected to make this eleven per cent. saving are somewhat obsolete. We have no data as to their condition, but probably they are no more so than thousands of others. Furthermore, it is safe to assume that it is just as feasible for most of the other plants to make a similar saving.

Installing instruments is not the alpha and omega of preventing boiler-room losses. That the training of the fireman is essential was recently brought out in a paper read before the Indiana Electric Light Association, which showed how fifty thousand dollars had been saved the first year by the Indianapolis Light and Heat Co. due to three things—training the fireman, installing boiler-room instruments and keeping a system of records. More than this, it is expected that the returns for the second year on the investment will exceed one hundred thousand dollars.

If this can be accomplished in one instance, it should be an incentive to others to pay more attention to this important department of the steam plant.

We Must Save That Fifty Million Tons

FIFTY million tons of coal must be saved this year. Engineers and firemen of power plants of every kind must save nearly all of it. The answer to the question, "Can it be done?" is, "It must be done."

It must be done because the doing of it means furnishing our overseas troops with the supplies and munitions with which to fight. Coal is a basic product; it is essential to the manufacture of steel and steel products, of which enormous supplies are vitally necessary to waging this people's war. Without coal industry is hopelessly crippled. And all industries must for long continue to carry peak loads. No need here to list the number of things that fifty million tons of coal can do toward the earlier ending of the war. Suffice it to say, we must save its equivalent.

Avoidable conditions that waste fuel in a power plant are as unpatriotic as is the person who now runs his automobile on Sunday, who refuses to stand when the national anthem is played, or who serves soda from a pretty fountain when his youth might make him a useful worker in a shipyard or elsewhere. It is a slacker condition any way one looks at it.

Yes, we know well that the engineers in such plants are not always to blame; the owner and manager have a responsibility here. But the Fuel Administration wants to know about such persons. Some of the owners and managers have not cared, heretofore. Mr. Myers, advisory engineer to the United States Fuel Administration, said the other night that they must care now.

This fifty million tons will not be saved alone by mandates. The Administrator does not want mandates. This coal will be saved more by coöperation than regulation. The gasless Sunday, which is the result of a mere request, keeps every unnecessary automobile in its garage; since the beginning of the gasless Sundays ten shiploads of gasoline have reached France that would not have been available if it were not for this unparalleled demonstration of America's will to win—and by a mere request.

We are sure that the power-plant men of the country will show as fruitful efforts in saving coal as automobile owners have in saving gasoline. They will guard the B.t.u.'s as zealously as they would prisoners of war or a food depot on the fighting front.

For our boys, we must, we will, save that fifty million tons. We will!

Six Billion Dollars

SIX billion dollars, the amount to be loaned to the United States Government on the Fourth Liberty Loan, is a gigantic figure—so great, in fact, that none but financiers who are accustomed to deal with large amounts can comprehend what the raising of this amount of money means, and even to them the vastness of the figures must be difficult to readily comprehend.

Six billion dollars are to be raised in twenty-one days, an achievement that is incomparable. From where and from whom it is coming? In part it is coming from you, Mr. Manager, Engineer, Fireman, Ash-handler and Day-laborer. In this stupendous effort there is no distinction of position and one man's dollar is just as good as another's.

Six billion dollars are to be raised by the people of this biggest, strongest and richest nation in the world, and every man should participate in the successful flotation of this Fourth Liberty Loan.

You bought bonds of the First, Second and Third loans, of course. Why not? You may think that you can not see your way clear to buy bonds of this Fourth issue. Think again!

Every man who is in a position to save even fifty or one hundred dollars a year should get in on this issue. Some may think that they are spending no more than is actually necessary and that there is no way of further reducing the living expenses of the family. No man is living so economically that there is not a chance for improvement, and therefore everyone should plan to deny himself and buy bonds of this issue.

The purchasing of six billion dollars' worth of bonds means that the people have obligated themselves collectively to forego luxuries and to some extent food and clothing that are not really necessary in order that the Government may have them or their equivalent. It is not going to be very hard to do without many things to which we have been accustomed. Six billion dollars in bonds will be subscribed. No doubt about it. But do not wait for others to do it. Let each one do his utmost for the Fourth Liberty Loan.

One Way We Can Help Russia

VAST territories to the eastward of Germany's prewar boundaries have come under the influence of the Germans. In this region, wrested from helpless Russia, are millions of men whom Germany will try to recruit. Threats and coercion will be employed, and great numbers of the victims may enter the Hun armies as the lesser of two evils.

Nothing can do so much to discourage Poles, Lithuanians, Finns, Ukrainians and others from accepting service in the German armies as a display of tremendous force and firm determination by the United States of America, for the winning of the war.

In no way, at the present time, can the power and will of America be shown to the world more strikingly than by the oversubscription of the Fourth Liberty Loan.

Faint hearts in the ravished Russian territory, yielding under pressure to the German plans, would be encouraged to revolt. Resistance to any draft or plan of recruiting would be assured.

If Germany is able to force the millions of Poles, Finns and others into armies, she may prolong the war for years and drain the world of its wealth. The best defense against this danger is the Fourth Liberty Loan, to strengthen the striking force of our armies, dishearten the Huns and increase opposition to the German military plans in all parts of Europe.

The United States Fuel Administration announces that for the purpose of the Fourth Liberty Loan no infraction of the lightless-night order will be permitted and no exceptions will be granted. This is quite right. An unpatriotic act cannot be patriotic.

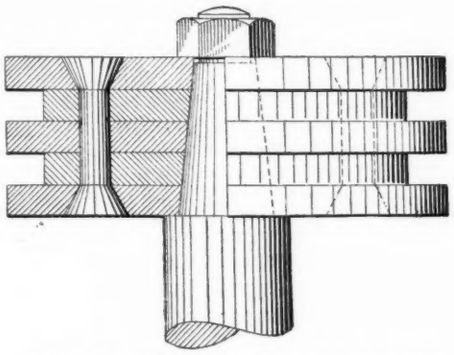
Many who thought the Fuel Administration's questionnaire "simply awful" have changed their minds since they received General Crowder's.

CORRESPONDENCE

In these and other columns "Power" wants to tell how you have decreased the fuel consumption in your plant. Since the fuel shortage, engineers have been thinking hard about conserving fuel. Thousands have made changes in equipment, in operating methods, and in modifications to boiler settings, etc., all of which have, in many plants, greatly cut fuel consumption. You owe it to the country to tell your fellow-engineers how you have saved coal. "Power" will pay for good articles that will help the other fellow save coal as you have saved it. Engineers must save at least 35 million tons this year. Let's have your story.

Piston Made of Boiler Plate

Some time ago I made a temporary repair to a winch engine, on one of our ships, that was broken when the follower bolt came loose and made "small pieces" of the



BUILT-UP PISTON FOR SMALL ENGINE

piston—in fact, too many to weld together. I cut out five pieces of ½-in. boiler plate with the oxyacetylene torch and riveted them together as shown. After finishing it in a lathe, I had a good piston which is still doing duty.

T. MULLIGAN.

Woodside, L. I.

Reserve Capacity of a Plant

The question often arises as to how much extra capacity a power house should have to meet any unusual demand or in case of accident. An extra unit or two is generally considered enough. Following is an experience in which extreme duplication did not avail.

In a railway station there were six units, five of them having a combined capacity of 750 kw. and the sixth 300 kw. Two of the units were coupled together and driven by one turbine, but each of the others was driven by its own individual turbine or engine. Two units were used during ordinary loads, the third one serving during rush hours. One day as the load began to come on, one of the pumps connected with the condensing apparatus of the coupled unit broke down and in about six hours a valve arm broke on one of the other units, necessitating shutting it down. There were, however, three units left intact, sufficient to carry the load, but a little later one of these burst a flywheel, damaging the plant, necessitating a shutdown of half an hour. This made the third accident in 24 hours, which is "going some."

Norristown, Penn. WILLIAM H. WATSON.

Equalizing Ammonia-Piston Clearance

A convenient method of equalizing the clearance of the ammonia piston on a Voss compressor is as follows:

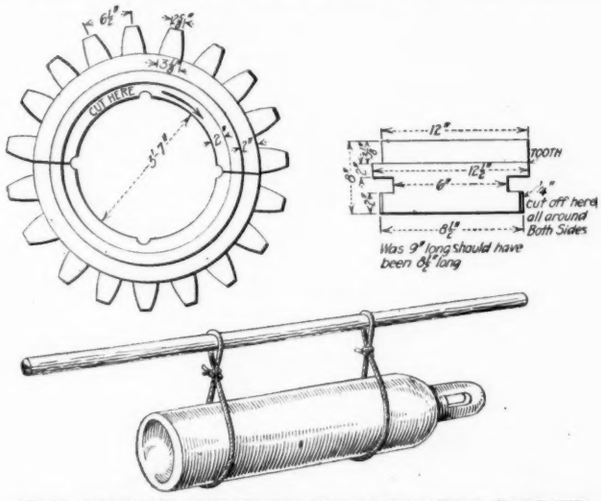
Place the crank on the dead-center and loosen the locknut on the ammonia rod. Screw up the ammonia rod until the piston strikes the head. Then tighten the locknut until it touches the coupling. Now carefully unscrew the rod and locknut together until a five-cent piece can be inserted between the locknut and the coupling. The clearance is then equalized and all that remains is to tighten the locknut.

Woodhaven, L. I. RALPH J. DALTON.

[Note that the author does not give the size and capacity of the compressor.—Editor.]

Oxyacetylene Cutting Job up in Cuban Mountains

While making repairs to a large engine that furnishes power for an inclined cableway located 1700 ft. above sea level, in the mountains of Cuba, two large pinions had to be replaced by new ones. The pinions were shipped up the incline before the engine was shut down for repairs, but when the old pinions were taken



HUB OF GEAR CUT WITH OXYACETYLENE CARRIED UP MOUNTAINS

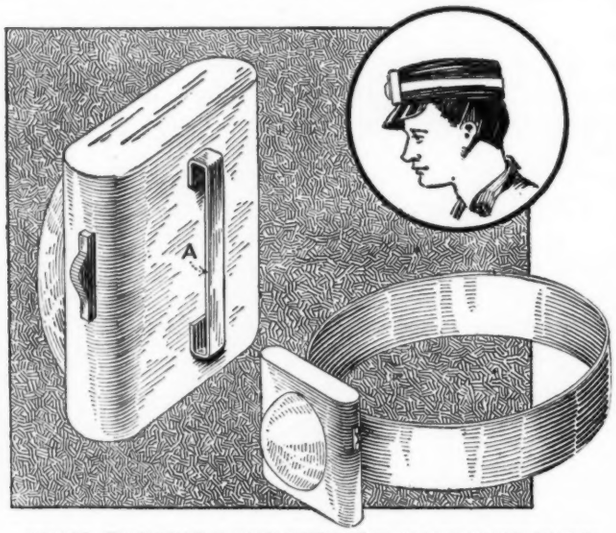
out it was found that the new ones were one-half inch too wide at the hub. There was no way to get them back to shop, at sea level, and in the small shop in the mountains there was no lathe or planer with which to do the job. So I was called upon to do some cutting. It was a question how I was going to get my oxygen and acety-

lene cylinders up the incline, which was a 12 to 25 per cent. grade. One incline was 200 ft. long; two were 2000 ft. long and one 6400 ft. long. The cylinder was strapped to a long pole and eight men took turns and carried the cylinders up to the top in 2½ hours. I cut a quarter inch off each side of the hub of the two pinions, which were 43 in. diameter, in 1¼ hours, the job requiring only a little filing on the inside edge.

Felton, Cuba. JOHN I. CRANFORD.

Head-Band for Battery Light

It is sometimes inconvenient to hold an extension lamp or the work may require two hands. The recent letters describing adjustable extension lamp cords bring to mind a lamp for use in dark corners which was mighty handy. Take a small flashlight, with the light in the side and solder a small strip of brass on the back as shown at *A* and, through it put a wide elastic head band.



SMALL BATTERY LAMP HELD BY AN ELASTIC BAND

In places where it is unhandy to hold a lamp, or where the space is too small for two to stand, this little headlight will be found handy.

Another convenient tool around a plant is a small mirror on a handle, to be used in the same way as a dentist uses his glass in the mouth to see some cavity he cannot see readily from the outside.

Norristown, Penn. WILLIAM H. WATSON.

Chart for Estimating Fuel Requirements

In *Power* for July 9, 1918, page 46, is a table of "B.t.u.'s per Boiler Horsepower at Various Efficiencies," in the preparation of which errors have been made. Although no express statement is made to that effect, this table presumably gives the B.t.u. to be supplied in the fuel per boiler horsepower-*hour*, for various boiler and furnace efficiencies. By definition, the boiler and furnace efficiency equals the heat equivalent of the boiler horsepower-hour divided by the heat supplied in the fuel per boiler horsepower-hour. That is,

Efficiency = 33,479 ÷ B.t.u. in fuel per boiler horsepower-hour.

The figures given in the table do not agree with this. For example, consider the value given by the table for 50 per cent. efficiency, which is 50,218.50 B.t.u. Evidently, if this quantity of heat were supplied, the efficiency would be 33,479 ÷ 50,218.50 = 66.7 per cent., and not 50 per cent, as given by the table. The author of the table seems to have computed the values by adding to 33,479 a certain fraction of 33,479, this fraction being the percentage of heat lost (which is equal to 100 — efficiency), divided by 100. This is incorrect because efficiency and per cent. loss should both be based on the heat supplied, *not* on the heat output, which is 33,479. The correct method of computation is given by the equation,

$$B.t.u.\ supplied = 33{,}479 \div \frac{efficiency}{100}$$

Thus the values in this table are none of them even approximately correct.

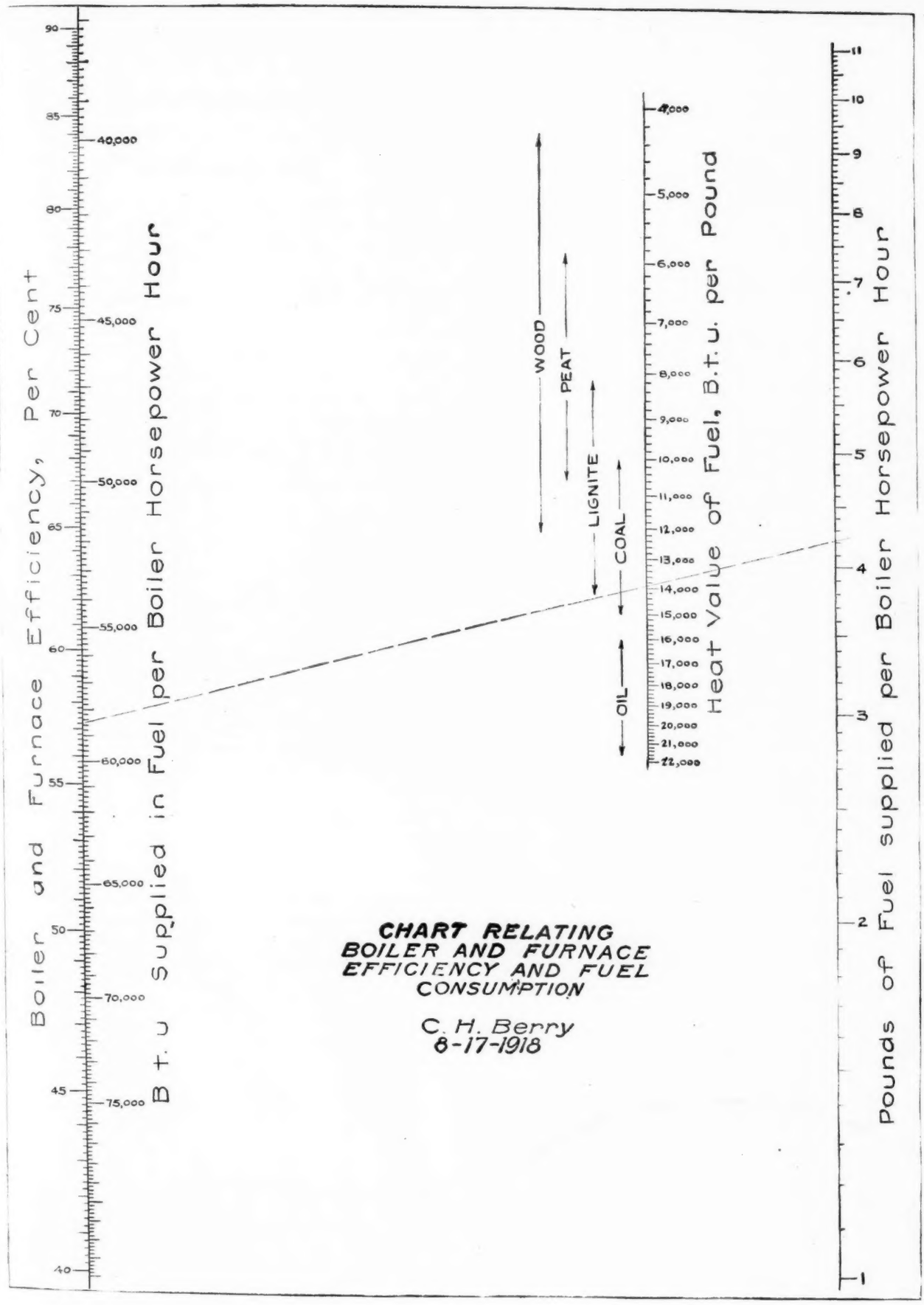
The second error in the table is of a different kind, but is hardly less serious than the first. It consists in the false appearance of extreme accuracy arising from the use of an unjustified number of figures in the results. As stated in the original article, the value 33,479 is equal to 970.4 × 34.5. The number 34.5 is established by arbitrary definition and may therefore be regarded as exact; but the heat of vaporization at 212 deg. F., 970.4 B.t.u. per pound, is determined by experiment, and is not known beyond the fourth or, at most, the fifth figure. Accordingly, the use of more than four figures in these computed results is incorrect and unjustified. Moreover, more than four figures would be of no value in engineering work, and three figures will be all that may properly be used in most work, because our use of the values will be in connection with observed weights, temperatures, pressures, etc., none of which can ordinarily be measured as close as the fourth figure with commercial operating instruments. Accordingly, the heat equivalent of the boiler horsepower-hour should be given at 33,480 B.t.u., and the tabular values should be given to the nearest ten B.t.u.

Instead of the table, a chart is more compact, and can readily be made to include more information. The chart given here has one line which gives the information that the table referred to was designed to give. Two scales on this line give corresponding values of the boiler and furnace efficiency and the B.t.u. supplied in the fuel per boiler horsepower-hour. The scales on the other two lines give the heating value of the fuel used, in B.t.u. per pound, and the pounds of fuel used per boiler horsepower-hour. A stretched thread or a straight line scratched on a sheet of celluloid will give an easy way of connecting corresponding points on the three lines. The values being given along any two of these lines, the third can be found easily, as shown in the figure. For example, if we expect an efficiency of 72 per cent. (which is equivalent to the supply of 46,500 B.t.u. per boiler horsepower-hour), and if we are to use a coal having a heating value of 13,200 B.t.u. per lb., we shall require 3.52 lb. of this coal per boiler horsepower-hour.

The range of the heating-value scale is extended to cover all commercial solid and liquid fuels, as indicated on the chart itself, and the scale of fuel weights covers the range of possibilities for efficiencies from 40 to 90 per cent.

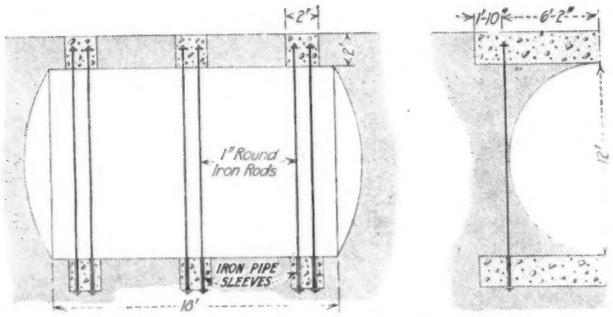
C. H. BERRY.

Cherrydale, Va.


Boiler and Furnace Efficiency, Per Cent
B t u Supplied in Fuel per Boiler Horsepower Hour
Heat Value of Fuel, B.t.u. per Pound
Pounds of Fuel supplied per Boiler Horsepower Hour
WOOD
PEAT
LIGNITE
COAL
OIL
CHART RELATING
BOILER AND FURNACE
EFFICIENCY AND FUEL
CONSUMPTION
C. H. Berry
8-17-1918

Buried Storage Tanks

With the increasing use of oil for fuel both under boilers and in the Diesel type of engine, the problem of storage facilities becomes more and more important and the various questions arising during the progress of such installations should be of timely interest.



METHOD OF ANCHORING BURIED TANK

It was recently the writer's privilege to assist in the installation of a 625-kv.-a. generating plant. Each of the alternators, four in number, is run by a 200-hp. direct-connected semi-Diesel oil engine operating at 257 r.p.m. In view of the location of the plant and the possibility of future extension, it was found necessary to provide for the storage of sufficient oil to operate over extended periods of time. There were installed two cylindrical steel tanks, each of 15,000 gal. capacity. The tanks measured 12 ft. in diameter by 18 ft. long. It was planned to bury them with the tops 2 ft. below ground level.

The location of the plant is within a few hundred feet of a large river and is on made ground containing a great deal of surface water. It therefore became apparent that concrete foundations must be provided to prevent settling when the tanks were full, to avoid straining pipe connections. Equally important was the problem of the tanks when empty, for then the tendency would be for the surface water to raise them.

The method used will become apparent on referring to the accompanying sketches. For each tank three concrete base supports were provided, at the front, center and rear respectively, and on top of the tanks similar concrete courses were poured. The novelty of the method lies in the use of the 1-in. iron rods connecting the upper and lower courses, so that, when the tanks are empty, the tendency to rise is arrested not only by the upper courses but also, through the connecting rods, by the lower courses. The tanks were rigged up separately to avoid unequal strains should one be empty when the other was full. It will also be observed that the rods extend through the bottom courses. This was done so that the tank could be placed in position before the rods were installed. The concrete courses were made 2 ft. by 2 ft. by 16 ft. long, although no definite data were available nor have any data on this subject been as yet discovered by the writer.

HENRY P. KAHN.

New York City.

Who Does Better?

There are shown herewith a chart from the CO_2 recorder and one from the steam gage used in our plant, which burns Iowa coal. We have two boilers 72 in. x 14 ft. set 30 in. from the grates; the combustion chambers are cleaned every two weeks. The stack damper is closed every time the fire-doors are opened for firing or cleaning fires. The dampers are operated automatically; the opening of any fire-door will close the stack damper. We keep the draft at 0.04 in. when the damper is open and 0.01 in. when the fire-doors are open. Unfortunately, we do not yet record the stack-gas temperature. These charts are typical of everyday operation. We consider that they indicate good performance, considering the coal and the volume of combustion space.

Sioux City, Iowa. G. STEELE.

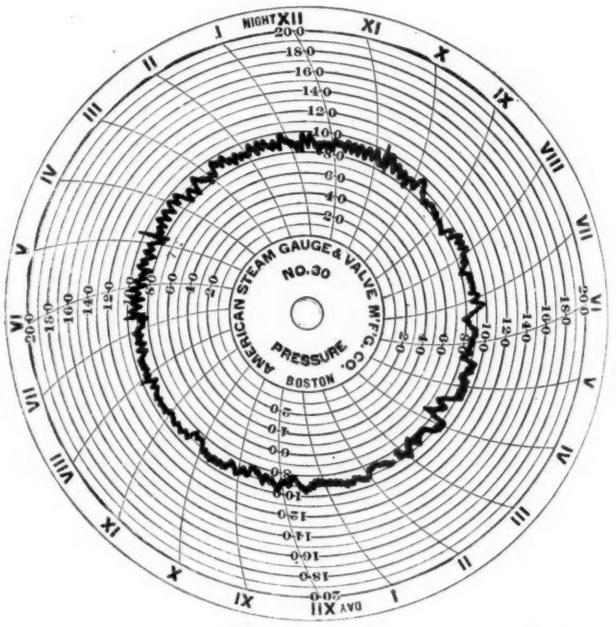


FIG. 1. STEAM-PRESSURE CHART, HAND FIRING, IOWA COAL

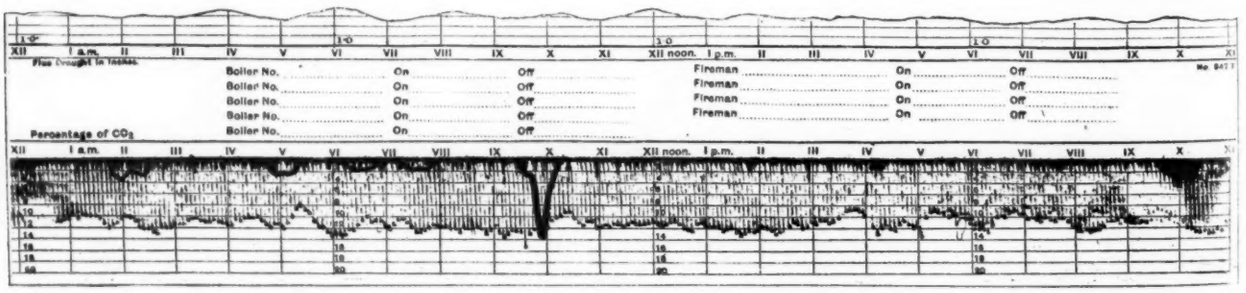


FIG. 2. CO_2 CHART, HAND FIRING, 30-IN. BOILER SETTING, IOWA COAL

INQUIRIES OF GENERAL INTEREST

Reason for Less Economy With Shorter Cutoff—What causes steam economy of an engine to fall off for shortening of the length of cutoff? E. H.

As the cutoff becomes shorter the weight of steam admitted to the cylinder is less, and as the amount of heat taken up by the cylinder walls is practically the same, the proportion of steam condensed is larger. The increased initial condensation offsets the increase in economy due to longer expansion.

Starting Pipe on Pump Discharge—What is the purpose of a starting pipe on a pump? J. S.

To facilitate starting, large pumps are generally provided with an extra opening on the main discharge, which is fitted with a valve of about one-eighth the diameter of the main discharge pipe and piped back to the suction well. This connection, called the starting pipe, can be used to start a pump gradually by allowing the air to escape and relieving the force chamber of pressure until the pumping capacity is sufficient to open the check valve, when the starting valve can be closed.

Counterbore of Cylinder—What is the object of counterboring engine cylinders? H. T.

One purpose is to form a limit to the working bore, so the piston may override the end of the bore and prevent the wear of the piston from forming shoulders at each end of its travel. Such shoulders would be an obstruction to the piston any time there might be a change in the length of the connections from keying up the engine. Another purpose of counterboring is to give a cylindrical surface from which the original center of the cylinder may be determined for lining up the engine, centering the piston rod or reboring the cylinder.

Development of Leak in Cast-Iron Heating Boiler—A cast-iron sectional boiler used for heating a private residence when started up for the season showed a leak that proved to be due to a crack in the upper portion of one of the sections. There was no leak when the boiler was shut down. Could the damage have resulted from accumulation of rust during the summer season? J. W. M.

It is likely that the crack developed from unequal expansion when the boiler was fired, probably due to starting up with too quick a fire. Rusting may have made the expansion stresses more severe by changing the form of the bearing surfaces at the joints or by causing a former crack to open wide enough to show leakage for the first time.

Saving by Higher Temperature of Feed Water—Where steam is generated at 115-lb. boiler pressure, what percentage of fuel saving would be realized from supplying feed water at 200 deg. in place of 110 deg. F.? H. A.

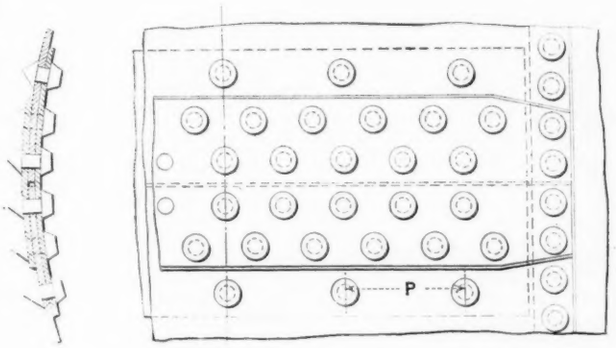
According to the steam tables a pound of steam at 115 lb. per sq.in. gage, or 130 lb. absolute, contains 1191 B.t.u. above 32 deg. F., and when the feed water is at a temperature of 110 deg. F. or 110 — 32 = 78 deg. above 32 deg. F., for its conversion into steam each pound must receive 1191 — 78 = 1113 B.t.u. With the feed water at a temperature of 200 deg. F., each pound of the feed water for conversion into steam would require 200 — 110 = 90 B.t.u. less. Hence the percentage of saving of fuel would be (90 × 100) ÷ 1113 = about 8 per cent.

Packing for Glass Gages on Gasoline Tanks—How can the gage-glass of a gasoline tank be packed to prevent leakage? Rubber packing rings and other ordinary kinds of packing have given considerable trouble. W. R.

Very good results can be obtained with ordinary rubber packing rings for use in glass gages for gasoline by giving the rings a thin coating of shellac varnish. Although this is a serviceable packing, from the highly combustible nature of gasoline the fixture should not be relied upon for constantly showing the level of gasoline in a tank, as accidental breakage of the glass or failure of the packing might be attended by serious consequences. Ordinary glass-gage fixtures should not be used unless the valves are opened only for a long enough time to observe the indication of the glass gage.

Efficiency of Butt and Double-Strap Joint, Triple-Riveted—What would be the efficiency of a triple-riveted butt strap joint, where the outer row of rivets are in single shear and the two inner rows are in double shear: that is, there are six rows altogether, three rows on each side of the butt; the sheets are $\frac{3}{8}$ in. thick and butt straps $\frac{5}{16}$ in. thick with tensile strength of 55,000 lb. per sq.in. of cross-section; rivet holes, $\frac{13}{16}$ in. diameter; pitch of rivets in outside row, $6\frac{1}{2}$ in.; pitch of both inside rows, $3\frac{1}{4}$ in.? W. P.

Having rivet holes $\frac{13}{16}$ in. = 0.8125 in. diameter, the cross-sectional area of rivets after driving would be 0.5185 sq.in. The thickness of plates $\frac{3}{8}$ in. = 0.375 in. and thickness of butt straps $\frac{5}{16}$ in. = 0.3125 in. Allowing the shearing strength of rivets in single shear = 44,000 lb. per sq.in., shearing strength of rivets in double shear = 88,000 lb. per sq.in., and the crushing strength of plates = 95,000 lb. per sq.in.; then for a unit length of joint P in the sketch = $6\frac{1}{2}$ in.,



BUTT AND DOUBLE-STRAP JOINT TRIPLE-RIVETED

(A) Strength of solid plate = 6.5 × 0.375 × 55,000 = 134,062 lb.

(B) Strength of plate between rivet holes in the outer row = (6.5 — 0.8125) 0.375 × 55,000 = 117,304 lb.

(C) Shearing strength of four rivets in double shear, plus the shearing strength of one rivet in single shear = (4 × 88,000 × 0.5185) + (1 × 44,000 × 0.5185) = 205,326 lb.

(D) Strength of plate between rivet holes in the second row, plus the shearing strength of one rivet in single shear in the outer row = [6.5 — (2 × 0.8125)] 0.375 × 55,000 + (1 × 44,000 × 0.5185) = 123,360 lb.

(E) Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row = [6.5 — (2 × 0.8125)] 0.375 × 55,000 + (0.8125 × 0.3125 × 95,000) = 124,667 lb.

(F) Crushing strength of plate in front of four rivets, plus the crushing strength of butt strap in front of one rivet = (4 × 0.8125 × 0.375 × 95,000) + (1 × 0.8125 × 0.3125 × 95,000) = 139,902 lb.

(G) Crushing strength of plate in front of four rivets, plus the shearing strength of one rivet in single shear = (4 × 0.8125 × 0.375 × 95,000) + (1 × 44,000 × 0.5185) = 138,595 lb.

As the strength of the joint would depend on consideration (B), namely, 117,304 lb. per unit length P, the efficiency = $\frac{(B)}{(A)} = \frac{117,304}{134,062} = 87.5$ per cent.

Saving Money in the Boiler Room

IN a paper read before the Indiana Electric Light Association T. N. Wynne told how $50,000 had been saved the first year by the Indianapolis Light and Heat Co., by properly training the firemen, installing boiler-room instruments to give complete data, and by keeping a most elaborate system of records. During the second year that the system has been in use it is expected that the return on the investment will exceed $100,000.

According to the experience of the author the best firemen were obtained by selecting young men and teaching them the job. The course of instruction should last at least two years and the time should be divided between operating and repairing. In the latter operation the student fireman familiarizes himself with the apparatus he is to operate, and as a result can fire with greater intelligence.

In these days when efficiency is so essential, the fireman must be intelligent so that he can understand his instrument and honest so that he will not make the instrument lie. In the average plant the fireman is turned loose on the coal pile and his job is to keep up steam. There is no reference made as to how he is to do this, as he is supposed to have completed his education before taking up the work. The experience of the company with which the writer was connected had shown that the average fireman needs watching, or he will do extremely wasteful things. As a general rule, especially in the inclined stoker or hand-fired plant, the fireman will fire and sit down, and follow this plan throughout the watch. He will try to make his periods of sitting last as long as possible by firing heavy and then letting the steam drop as far as he dares before starting a new cycle. A remedy for this is not to allow the fireman to sit down at all, but have him stand an eight-hour watch and allow no chairs or benches in the boiler room. With this ruling in force the fireman interests himself in his work, and the result is better and steadier fires tending toward higher economy.

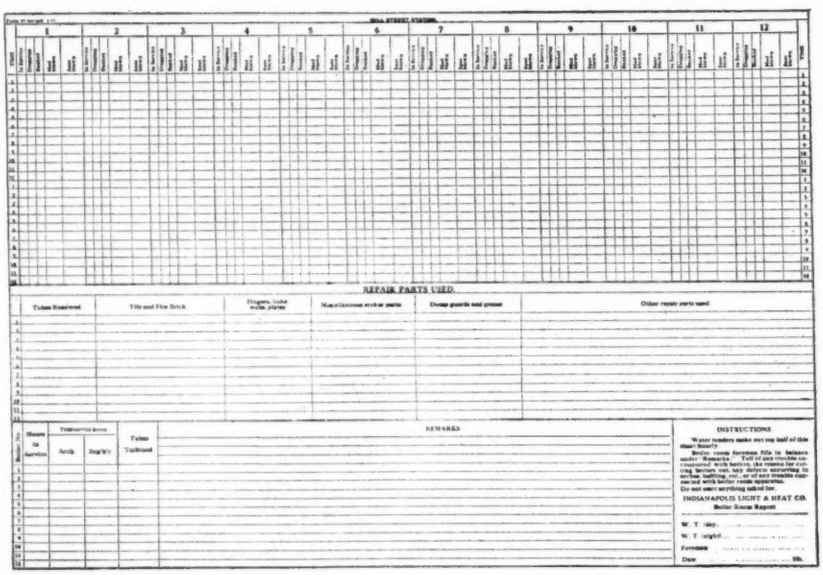


FIG. 1. COMPLETE BOILER-PLANT RECORD

A fireman should never be required to do any other work than attend to his fires, except perhaps in very small plants, as it gives him an excuse for poor fire regulation. He cannot be blamed for having a wasteful fire if he is at that moment packing a pump.

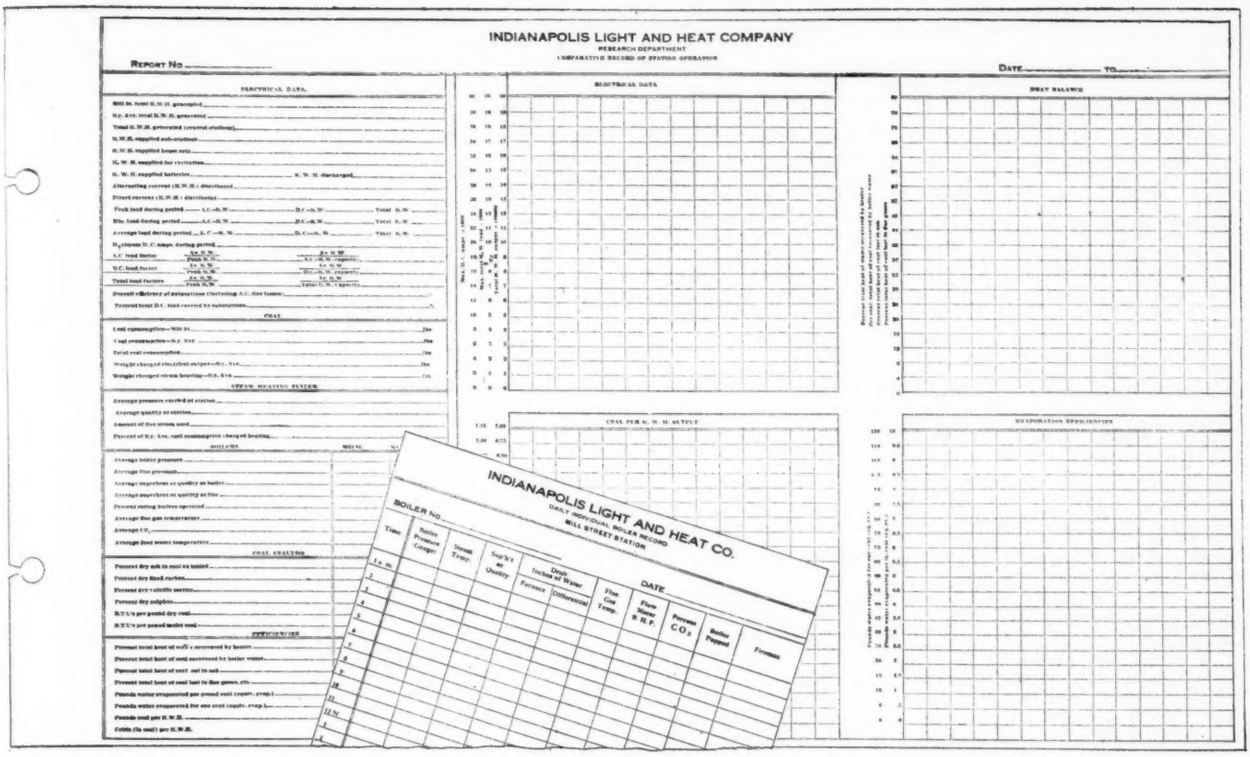
To determine the degree of economy being obtained in the boiler room, a certain number of instruments are absolutely necessary. A boiler and grate has maximum efficiency at a certain rating, depending somewhat on the fuel used. This rating should be determined by actual boiler tests. Usually the point of greatest economy is around 160 per cent. of rating, and the boiler should be operated at this load continuously, except of course during the peak, when it is usually necessary to force it harder. When operating a boiler in this way the underfeed stoker has a decided advantage. It can be operated during off-peak hours at the point of highest efficiency, and as has been demonstrated, crowded to 400 per cent. of rating during the peak load. Carrying the boiler at this high rating is decidedly uneconomical, but it does not entail the loss caused by banking boilers. The instrument to indicate or record the rating at which the boiler operates is the steam-flow meter, and no plant of any size should be without one.

It is obvious that a calorimeter to give flue temperatures should be employed, and a coal-weighing device of some sort is a necessity. A sample of coal from each car should be analyzed.

Special pains must be taken at all times with the fire. At normal loads a thin, fast fire is probably the best. With a thin fire holes are more likely to occur than in a thicker one, hence the thin fire needs more attention, and this may account for the fact that the thicker fire predominates. A draft gage, particularly if it is of the two-pen recording type connected over the fire and at the uptake, will show what is going on in the boiler, indicates the condition of the fire better than anything else and lessens the necessity for opening the inspection door to look at the fire, which always cools the gases temporarily. When the first boiler tests are made, the draft over the fire necessary for different thicknesses of fuel bed and boiler ratings can be determined. These values can be plotted so that for any rating the thickness of the fire and the draft necessary are known, and in the case of stokers the speed at which to operate them. Other draft connections can, and in some cases should be made in the ashpit and before each baffle, so that the drop through the setting can be readily determined and leaks in the baffle or elsewhere detected.

The temperature of the uptake gases is a good indication of the condition of the boiler-heating surface and of the economy being obtained. When the tubes are covered with soot or scale, the water will not absorb as much heat as when the surfaces are clean, so that the temperature of the flue gases will be higher. As soon as the pyrometer shows that the temperature of the flue gases is rising, one of the three things, or all, can be looked for: Soot, scale, or leaky baffles. Pyrometers are made so that one instrument may be used for a number of boilers, each boiler having its own thermocouple leading back to the instrument.

Ascertaining the CO_2 content of the flue gases is important as it indicates the efficiency of combustion. For average Indiana coal and the required amount of air to burn it, 12 per cent. CO_2 is a good figure. Low CO_2 in the flue gases is caused by an excess of air, insufficient air or an improper mixture of air and gases. The most common fault, however, is excess air, and in many cases this is caused by a leaky setting. A drop from 16 to 10 per cent. CO_2 means a 5 per cent. waste of fuel. A drop from 10 to 6 per cent. means a 12 per cent. loss and a drop from 6 to 2 per cent. means that the waste fuel is 57 per cent. The boiler-room list should then include a CO_2 instrument. If it can be a continuous chart recorder so much the better, but if it is a hand apparatus, let the sample of gas be taken when the fireman is not looking.

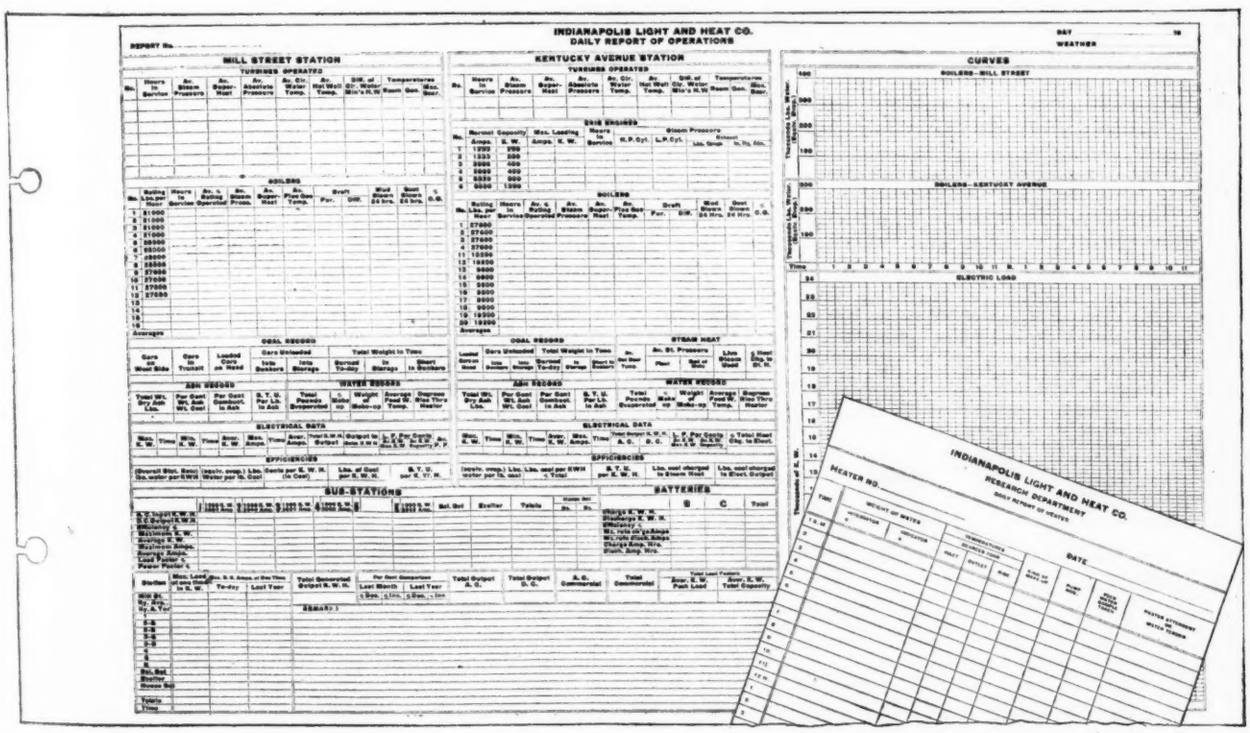


FIGS. 2 AND 3. COMPARATIVE RECORD OF STATION OPERATION AND DAILY INDIVIDUAL BOILER RECORD

In the foregoing have been given the more important instruments necessary for good economy in the boiler room. These instruments should be calibrated and taken care of so that they will give accurate indication of the conditions existing. The list may be supplemented by other instruments that are important, but not necessary, such as furnace-temperature pyrometers, a coal-sample grinder, apparatus for determining sulphur content, etc.

The installation of these instruments will do but little good if the results obtained are not properly filed and tabulated for future reference. A form should be provided for daily boiler operation that includes all readings of any value. For each boiler these readings should be taken simultaneously as often as the conditions dictate, and care should be taken that the fireman does not allow his fire to drop down between readings.

Another form should be used for the heater, and still another for the coal and ash. The former should show the



FIGS. 4 AND 5. DAILY REPORT OF OPERATIONS AND HEATER REPORT

inlet and outlet water temperatures and the amount of water used. The second blank mentioned should show the weight of coal and ash for a 24-hour run, the kind of coal, where it is from, how much is on the way, and in addition the amount of storage coal.

Other useful information is a maintenance form including the repairs made on boilers, stokers, brickwork and auxiliaries. This information not only apprises the chief engineer of the repairs being made, but will also give boiler hours on the equipment. It is a good thing to know how long a stoker can operate without entire replacement, or which kind of firebrick lasted the longest under the same conditions. These are good data for reference when purchasing new equipment, and provide a source of information for anticipating needs in the boiler room.

All of these reports with those from other parts of the station are collected at a certain time and consolidated into one station daily report. The best time for collecting these reports is midnight, so that from then until morning a clerk can consolidate the information and have the daily report ready for the chief engineer in the morning. By looking it over when he comes on duty, he has a complete record of the station operations for the previous 24 hours and can tell the mistakes made in operation, what apparatus needs attention, or the effect of changes made a day or two before.

A monthly report and a yearly summary should be compiled, the former giving the average results for a month and comparing the month in question with the eleven preceding months. Such information as pounds of coal per kilowatt-hour, B.t.u. per kilowatt-hour, load, pounds of water evaporated per pound of coal, etc., should be included and the comparisons made by means of curves. The same outline applies in a general way to the yearly summary.

Useless information or too much detail should not be included in the report. It is important that from the readings taken accurate computations should be made, that the final report should be looked over every day by the chief engineer, and that he follow out whatever suggestions he receives from an analysis of them. If this system is not followed out, it is obvious that the whole plan is useless. When it is followed conscientiously, big dividends will result. As expressed at the beginning of this article, the Indianapolis company realized $50,000 the first year the system was put into force, and with coal and material prices at the present high figures the return on the investment this year should run over $100,000.

Smokeless Combustion with Chain Grates*

By Thomas A. Marsh
Chief Engineer, Green Engineering Co.

The chain grate has been in the field since 1871 in this country, and furnace designs giving smokeless installations under the many varied conditions are quite definitely established among combustion engineers. Chain-grate manufacturers and their engineers have taken an active part in the development work which has led to this satisfactory situation, having first devoted efforts in this direction some fifteen years ago. This was prior to the existence of a large number of our present types of stokers, as well as to the establishment of but a very few organized smoke departments.

In the early days the majority of chain-grate installations were greatly lacking in proper furnace proportion and design, but in spite of the fact that these initial stokers were set directly under the boilers, observations brought out two significant facts: First, that even in the absence of adequate furnaces chain grates were good performers from a smokeless standpoint; and second, boiler tests indicated high hydrocarbon losses, due to insufficient space for proper combustion.

The campaign for setting boilers higher to provide ample furnace space for more complete combustion was most difficult. Engineers, architects, owners and others disapproved on account of the extra cost, and it was not until city smoke departments, backed by city ordinances, began to exert influence that the problem was simplified. For instance, the Chicago Smoke Department is very specific regarding boiler height and furnace proportions, as are such departments in other cities.

From year to year furnace volume has increased. Ten years ago furnaces having 2 cu.ft. per sq.ft. of grate area were quite common; today, we have furnaces providing as high as 20 cu.ft. per sq.ft. of grate area, and those having 6 to 8 cu.ft. are the general rule. It is becoming quite a necessity to discuss furnaces in terms of cubic feet per square foot of grate surface.

Let us consider how these large furnaces affect their settings. Ten years ago vertically baffled boilers of the B. & W. type were often set as low as 7 ft. from the floor line to the bottom of the header. Now 12 ft. is considered none too great, although this type of boiler with chain grates will perform within the Chicago ordinance at 200 per cent. rating when set only 9 ft. under the header. Accordingly, this large furnace is not provided entirely to secure smokelessness.

Horizontally baffled boilers set 7 ft. under the header will give similar results, and boilers of the return-tubular type, set 6 ft. 6 in. to the bottom of the shell, as well as Stirling boilers set 3 ft. 6 in. to the center line of drum, are equally smokeless.

High-set boilers are the result of the effort to secure complete combustion of high-volatile coals in the furnace. Tests results taken through years of practice with high-and-low-set boilers indicate that between the heights of 7 and 10 ft. on vertically baffled boilers there is fully a 12 per cent. difference in efficiency in favor of the latter. This difference may be credited solely to a more complete combustion of the hydrocarbon gases. Engineers are realizing rapidly this fact, and better furnace designs are coming. Smokeless combustion was the first inducement that led to the general discovery of the improved efficiency obtainable. It is well said that while smoke is not, in itself, a great loss, it is almost invariably the telltale indicator of other reprehensible plant conditions which entail losses often as high as 20 per cent.

The fuels that are customarily burned on chain grates are the bituminous, tarry, smoky coals which, without question, are under improper conditions the worst smoke producers obtainable. Chain grates are well adapted, fortunately, to these fuels, and smokeless combustion is easily to be derived. In the words of W. L. Abbott, chief engineer of the Commonwealth Edison Co., Chicago, "Illinois and Indiana coals were originated to be burned on chain grates." Certainly smokelessness is easily obtained even with such fuels, with proper furnaces and chain grates. The necessary dimensions to insure smokelessness with chain grates are standard in most of our cities. Arch design, air distribution and air exclusion and other features are improving.

At one time an efficiency of 72 to 75 per cent. with chain grates and Western coals was considered impossible. Today such results are obtained repeatedly with proper furnace designs; these results are due to complete combustion in the furnace. Stokers, in many instances, have been accused of being responsible for low economy, when as a matter of fact the loss was due to a deficiency in furnace space.

Many Eastern coals, owing to a lower percentage of volatile hydrocarbons, do not require the furnace volume demanded by Western coals. As an example, compare Pocahontas and New River, with 12 to 14 per cent. volatile matter, with Pittsburgh No. 8, at 35 per cent., or more than double the amount. Yet there has been no discrimination of furnace to burn this greatly increased percentage of volatile. Illinois and Indiana coals have 35 per cent. volatile, and some Colorado coals have close to 60 per cent.

The general message, therefore, to be impressed is:

1. Learn to analyze furnaces as to the number of cubic feet of furnace per square foot of grate.
2. High-moisture fuels, sub-bituminous, lignite and Iowa

*Paper presented at the convention of the Smoke Prevention Association at Newark, N. J., August, 1918.

high-ash coals are now being burned successfully in many plants on chain grates, the problem simply being one of furnace design.

3. There are comparatively few boiler settings existing today which could not have their efficiency improved with no change in apparatus, but by increasing the proportions of the furnaces.

4. Engineers should realize that departments of smoke prevention are asking for the minimum dimensions to insure smokelessness; frequently an appreciable improvement in efficiency will be obtained by installing still more ample furnaces. Best practice is in this direction.

5. The general plea, therefore, is for more ample furnaces and the higher efficiencies beyond the minimum required for smokelessness.

Fuel Meeting in New York

On Saturday evening, Sept. 28, several hundred engineers and plant owners of New York City and adjacent towns in New Jersey attended a patriotic fuel meeting at Cooper Union, New York City. The meeting was arranged by a joint committee of members of the National Association of Stationary Engineers, the Marine Engineers' Benevolent Association and the Ocean Association. Frederick Felderman, of N. A. S. E. No. 44, New York City, presided. Mr. Felderman laid particular emphasis upon the necessity of the coöperation of plant owners with engineers in the latter's efforts to save fuel. David Moffat Myers, advisory engineer, United States Fuel Administration, pointed out that this year we must mine 100,000,000 tons more of coal than we mined in 1917, and that then there would be a certain shortage of 50,000,000 tons which would have to be made up by the coöperation chiefly of power-plant men. To make the steel products so many of which are munitions of war requires coal. This coal must be had and it must be made available to these industries by every one doing his bit to save all he can of this basic product. Mr. Myers again made it clear that in regard to the central-station vs. isolated-plant situation the Fuel Administration stands only for a square deal. Wherever exhaust steam is used sufficiently and where unnecessary amounts of it are produced, there is no reason why a plant should not get its coal and be permitted to run. Engineering analysis alone will determine the status of plants. Relative to the questionnaire, Mr. Myers said that it was extremely urgent that some form of questionnaire be put forward quickly that a start might be made in saving coal. "A pretty good program started on time is better than a perfect program started after the game is lost," said Mr. Myers. That was the situation when the questionnaire was prepared. "Today the owner has got to care about the suggestions for saving fuel advanced by his engineers." This Mr. Myers said in his plea for coöperation between owners, engineers and firemen. Speaking of the losses in the use of fine anthracite, much of which is used in and around New York, he laid particular emphasis upon the fact that the greatest loss is due to the uptake damper being too wide open most of the time.

Mark L. Requa, Director of the Oil Division of the Fuel Administration, said that a French senator not long ago had made the remark that a drop of petroleum was equal to a drop of blood. "Our wants at home must come second," said Mr. Requa, "for the machines of war that protect the bulwarks of Liberty must be supplied, and will be supplied." He said that an airplane required on an average of 30 gal. of gasoline per hour to keep it in commission on the battle front. The pipe lines from Oklahoma and the Gulf ports to the Atlantic seaboard are now loaded to their full capacity; tank cars are moving at a daily average mileage never before equaled, and more ships than ever before are carrying oil. While there will be a shortage of production, Mr. Requa was indeed pleased to announce that our reserve stock of petroleum was such that we would have enough to see us through until the end of the war, provided reasonable care was observed in its use. A new well has been found in Texas which will undoubtedly meet future requirements; this well is being developed. The increase in the consumption of gasoline for the first six months of the present year is 8,000,000 bbl. The kerosene supply has greatly diminished and soon will become extremely acute. The gasless Sundays have already enabled the Fuel Oil Division to send to our army in France fifty shiploads of gasoline that would not have reached there if it had not been for these Sundays, which, it will be remembered, were asked for merely in the form of a request. This demonstrates the deep determination of a democratic people to win this war.

Captain Adams, of the 22nd Engineers, made a most stirring address, appealing to the patriotism of engineers and firemen. Mr. Robinson, Director of Oil Conservation of the Oil Division, presented many interesting statistical figures relative to oil consumption and production and the uses by particular industries. His bureau has adopted the slogan, "Stop the Leaks and Save the Drops." This slogan he wished the audience to carry away with it.

Other speakers were J. D. Taylor, chief engineer, Museum of Art, New York City, Mr. Delahanty, of the Marine Engineers' Benevolent Association, and Timothy Healy, of the International Firemen's Union. This was certainly the most impressive fuel meeting ever held in New York and perhaps in the country. There will likely be more of them.

New England Power Interconnection

At a cost of over half a million dollars the systems of the New England Power Co. and of the Edison Electric Illuminating Co. of Boston are to be interconnected by a high-voltage tie-line in time to facilitate the handling of the coming winter peak load, according to plans recently approved by the Massachusetts Gas and Electric Light Commission. The connection of these two largest electrical utilities in New England is expected to increase the power supply in the industrial territory served by the New England Power Co. by about 15,000 kw. of off-peak energy available at the L Street plant of the Boston company. This output is to be supplied without the expenditure of a single dollar in generating-station equipment at Boston, and it would be hard to find a better example of the benefits of interconnection under war conditions.

For more than a year there has been a good deal of activity in Massachusetts and Rhode Island central-station circles relative to interconnection possibilities. The New England Power Company's large hydro-electric system has for some time been connected with the steam-turbine plant

FOURTH LIBERTY LOAN ENTHUSIASM
"NOTHING DOING"
PRESIDENT WILSON'S REPLY TO AUSTRIA'S PEACE PARLEY
GREAT STUFF TO GET STEAM UP WITH.

From the Philadelphia Record

of the Narragansett Electric Lighting Co. in Providence and with the plants of the Worcester Electric Light and other companies in Massachusetts. A connection with the New England system recently proved of great value to the Blackstone Valley Gas and Electric Company, which had a turbine of several thousand kilowatts' rating go out of commission unexpectedly; and conversely, the connections with the central stations have been very useful to the New England company, as the available water power in its plants has been developed and utilized to the limit set by present financial conditions. Comprehensive studies have been made of the benefits of interconnection of systems extending virtually from Portsmouth, N. H., to New London, Conn., and the future is likely to see a good deal of this sort of thing.

Returning to the New England Power-Boston Edison matter, however, it is interesting to note that the capital necessary for this interconnection has been approved by the Federal authorities, since by this construction and its skillful operation, a substantial increase in the amount of power available for war-industry plants and public utilities will be secured. The Boston company is to provide the capital for the line, but the New England company is to guarantee to take from 30,000,000 to 40,000,000 kw.-hr. a year from it in off-peak energy, or else to pay a fixed charge of about 2.5 mills per kw.-hr. It is expected that the actual price of the energy delivered to the power company will be in the vicinity of 8 mills per kw.-hr., depending upon the cost of production at Boston, which in turn is largely influenced by the price of coal. As the line is used more and more by the Edison company in the supply of business in the rapidly growing industrial territory centered around Framingham, the fixed charge guaranteed by the power company is to decrease. The effect of the interconnection should be to improve the station load-factor at Boston and besides giving needed facilities to the interior industries, furnish an opportunity for utilizing surplus water power when available.

Electrolysis of Condenser Tubes

A recent issue of London *Engineering* contains the results of an analysis of two cases of condenser-tube corrosion made by the Material Prüfungsamt near Berlin, Germany. One brass originally contained the following percentages of metals: Copper, 70.5; zinc, 28.8; lead, 0.21; tin, 0.28; iron, 0.08. The corroded alloy contained: Copper, 97.4; zinc, 0.69; lead, 0.06; tin, 0.46; iron, 0.08. In the other case the original analysis yielded the following percentages: Copper, 59.2; zinc, 40.37; no tin; iron, 0.32; lead, 0.24. The corroded alloy had the composition: Copper, 96.76; zinc, 1.29; no tin; iron, 0.10; lead, 0.05.

In both cases the corrosion had bleached out the zinc and had also diminished the small percentage of lead, while there was little or no change in the iron. That the ordinary water of the supply main may give rise to considerable differences of electric potential is shown by the water of Charlottenburg, a suburb of Berlin. In this water couples of zinc and brass acquire a potential difference of 0.888 volt. In view of the actual wide uses of substitutes for metals and alloys the Prussian government has drawn attention to the danger of electrolysis.

Drafted Men Inducted Into the Navy

The securing of men for the Navy, with the exception of those students who are to be enrolled in the Naval Section of the Students' Army Training Corps, will be controlled by the Bureau of Navigation through the Provost Marshal General's office. It has been agreed that the Provost Marshal General will induct 15,000 men monthly upon the request of the Bureau of Navigation into the Navy. Of these 15,000 men the Bureau of Navigation has the privilege of receiving 6,500 *men by voluntary induction. It is stipulated that the Bureau will locate these* 6,500 *men by name and request individually the induction of these men by the Provost Marshal General.*

Besides these 6,500 men individually inducted the Navy will receive 8,500 men from the run of the draft. It is understood that these 15,000 men are all from Class A-1. As soon as the Bureau of Navigation issues a call upon the Provost Marshal General for the 8,500 men the draft board will send into the main mobilization station these men in quotas apportioned by the Bureau of Navigation.

Two Thousand Barrels of Oil Saved per Day

By urging the cementing of oil wells in the North Cushing field of Oklahoma, to keep out the detrimental flow of water, the Bureau of Mines has succeeded in increasing the production of oil from fifty wells more than 2000 bbl. a day.

Aside from the commendable saving for war uses, this lesson in practical conservation will add $4500 a day to the operators' gross income, and if the increased oil yield continues for one year, a not oversanguine expectation, there will be an addition of more than three-quarters of a million barrels of oil for war purposes, and $1,640,000 more in the pockets of the operators.

It is estimated by A. A. Hammer and V. L. Conaghan, the Federal oil and gas inspectors for Oklahoma, who have charge of this campaign, that the total cost of excluding the water from the fifty wells was $10,000, which means a return of about $165 for each dollar invested.

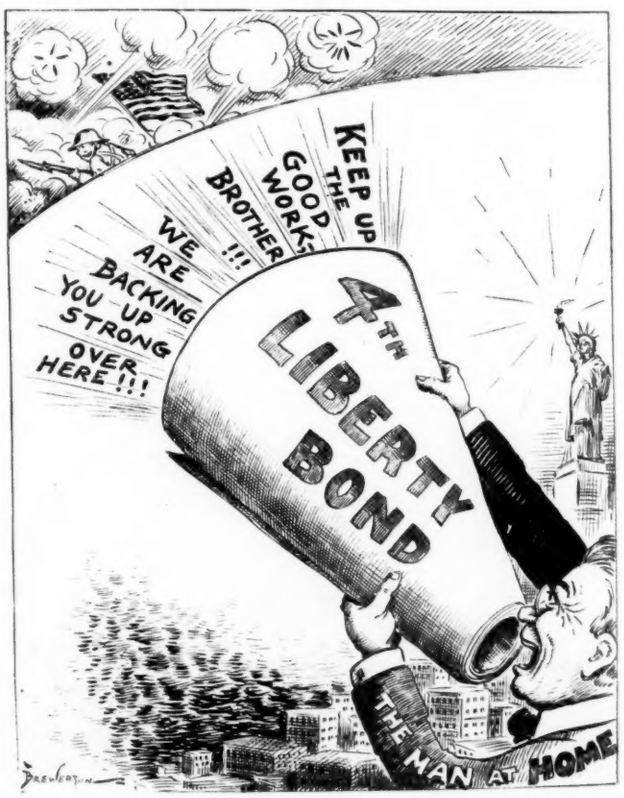
Lightless Nights Throughout the State

Mercer P. Moseley, Chief of Conservation for New York State, thus defines the scope and application of the "lightless night order":

In New York State the lightless night order applies to all municipalities and electric companies without exception. To avoid discrimination and consequent friction, municipalities served by hydro-electric plants will hereafter observe the general rule.

Skill and Genius Contrasted

It is easy to make a thing of intricate shape if of no particular predetermined size or shape, it takes *skill* to duplicate it, but it takes *genius* to produce many such parts, all alike and cheaply.—*Marine Engineering.*



New Publications

RECOVERY OF GASOLINE FROM NATURAL GAS BY COMPRESSION AND REFRIGERATION

In a 150 page, 9 x 5 bulletin By W. P. Dykenma, officially designated as Bulletin 151, the Bureau of Mines treat of the compression and refrigeration process for the recovery of gasoline from natural gas from the viewpoint of the practical engineer and the business man. Pages 72 to 81 inclusive, are devoted to descriptions of the machines used in the compression plant, devoted particularly to engines, both steam and gas, air compressors, boilers, pumps and auxiliary machines as used in this industry. The bulletin is free to those who write for it.

BUREAU OF MINES BULLETINS

For those who are taking an interest in the economical use of fuel in these times of scarcity, the Bureau of Mines has for free distribution a number of publications that will prove helpful. Some of these, previously out of stock, have been reprinted and are now available. Here are some of the papers that may be obtained free of charge by addressing the Director of the Bureau of Mines, Washington, D. C.:

Bulletin 39, "The Smoke Problem at Boiler Plants."

Bulletin 40, "The Smokeless Combustion of Coal in Boiler Furnaces."

Bulletin 58, "Fuel-Briquetting Investigations."

Bulletin 85, "Analyses of Mine and Car Samples of Coal Collected in the Fiscal Years 1911 to 1913."

Bulletin 97, "Sampling and Analysis of Flue Gases."

Bulletin 123, "Analyses of Mine and Car Samples of Coal Collected in the Fiscal Years 1913 to 1916."

Bulletin 135, "Composition of Coal and Design of Furnaces."

Bulletin 145, "Measuring the Temperature of Gases in Boiler Settings."

Bulletin 156, "The Diesel Engine; Its Fuels and Its Uses."

Technical Paper 1, "The Sampling of Coal in the Mine."

Technical Paper 2, "The Escape of Gas from Coal."

Technical Paper 8, "Methods of Analyzing Coal and Coke."

Technical Paper 9, "The Status of the Gas Producer and of the Internal-Combustion Engine."

Technical Paper 35, "Weathering of the Pittsburgh Coal Bed at the Experimental Mine near Bruceton, Penn."

Technical Paper 55, "The Production and Use of Brown Coal in the Vicinity of Cologne, Germany."

Technical Paper 76, "Notes on the Sampling and Analysis of Coal."

Technical Paper 80, "Hand Firing Soft Coal Under Power-Plant Boilers."

Technical Paper 97, "Saving Fuel in Heating a House."

Technical Paper 113, "Some Properties of the Water in Coal."

Technical Paper 133, "Direction for Sampling Coal for Shipment or Delivery."

Technical Paper 137, "Combustion in the Fuel Bed of Hand-Fired Furnaces."

Technical Paper 139, "Low-Rate Combustion in Fuel Beds of Hand-Fired Furnaces."

Technical Paper 140, "The Primary Volatile Products of the Carbonization of Coal."

Technical Paper 144, "The Quick Determination of the Inflammability of Coal Dust and Air Mixtures."

Technical Paper 170, "The Diffusion of Oxygen through Stored Coal."

Technical Paper 172, "Effects of Moisture on the Spontaneous Heating of Stored Coal."

Technical Paper 180, "Firing Bituminous Coals in Large House-Heating Boilers."

Technical Paper 184, "Weights of Various Coals."

Technical Paper 199, "Five Ways of Saving Fuel in Heating Houses."

Technical Paper 204, "Economic Operation of Steam Turbo-Electric Stations."

Technical Paper 205, "Saving Coal in Boiler Plants."

Personals

George Eagleton, formerly chief engineer of the Petroleum Iron Works Co., Sharon, Penn., has been appointed master mechanic.

Frank B. Gilbreth, having received an "honorable discharge for disability incurred in line of duty," has resumed his practice as an efficiency engineer. Mr. Gilbreth's work, especially in time study, has gained for him an international reputation. His address is 77 Brown St., Providence, R. I.

D. T. Davis of the law firm of Davis, Symmes & Schreiber, 55 Liberty St., New York City, will act as counsel for the New York State Fuel Administration, having been appointed by D. W. Cooke, State Fuel Administrator. Mr. Davis is a graduate of Columbia University Law School, class of 1898.

H. E. Willer has been appointed manager of bituminous distribution for the State of New York. Mr. Willer was for many years assistant to the vice president of the traffic department of the New York Central lines. During the last year he has devoted considerable time to army-transportation affairs.

Harold A. Almert, initially administrative engineer in Cook County for the Fuel Administration, has now been appointed Director of Conservation for the State of Illinois. It is a big position with a capable man in charge. Mr. Almert will have supervision over all phases of conservation, including lightless nights, skip stops, limiting hours of service in certain industries, all domestic fuel applications, misapplications of fuel in power and heating plants and in the industries, consolidation of ice plants, laundries, etc. Coöperation and education rather than compulsion will form the keynote of the policy to be adopted.

Miscellaneous News

One of the Big Boilers at No. 2 furnace of the Carnegie Steel Co., South Mill St., Newcastle, Penn., let go on Sept. 14. Nobody was hurt.

Four Boilers Exploded at the Rillton (Penn.) mine of the Westmoreland Coal Co. on Sept. 23, instantly killing two firemen, severely injuring two others and endangering the lives of hundreds of miners who were at work in the shaft, and who fled when the explosion occurred.

A 75-hp. Tubular Boiler Exploded at the Keystone Mills, Gulf Mills, Penn., on Sept. 17, injuring five men and causing several thousand dollars damage to machinery and property. The boiler, which was apparently in proper working order, was blown from the middle of a nest of three, carrying away the entire side of the engine room. The accident has temporarily thrown about one hundred employees out of work on Government orders.

A Steam Pipe Exploded at the Burrus Mill and Elevator Co.'s plant, Fort Worth, Tex., on Sept. 22, scalding the chief engineer and assistant, who were trying to stop a leak with a pipe-joint clamp. One of them never regained consciousness and died three hours after the accident. The other, who suffered intensely, battled with death until the next day. Two other men who were in the engine room at the time received severe burns, but are expected to recover. What caused the pipe to separate is not known, but one report is that the men jacked a 10-in. tee off the pipe while steam pressure was on, letting loose on them hundreds of pounds of steam and a great quantity of boiling water, and the engine room being small and cramped the men had no chance to save themselves.

Business Items

The Walworth Manufacturing Co. has, at the urgent request of the War Industries Board, with the idea of releasing labor, and conserving material and fuel, adopted as a war measure the following (all of which is now effective, but with the provision that work in process or stock on hand may be worked up): The discontinuance of the manufacture of its 6-in. Stillson wrench; the discontinuance of the manufacture of the wood-handle Stillson wrench in all sizes (making only the steel handle); and has adopted the "War Finish" as its standard finish for wrenches for the duration of the war with no change in patterns or quality.

Trade Catalogs

Hunt Storage Battery Industrial Trucks. C. W. Hunt Co., Inc., New York City. Bulletin 18-2. Illustrating and describing their standard machines and other types equipped with side and end dumping bodies and crane. A copy of this pamphlet may be had free upon request.

New Construction

PROPOSED WORK

Mass., West Dudley—The Burmese Paper Co. plans to build a 1 story, 30 x 50 ft. hydro-electric power plant. Estimated cost $50,000.

Conn., Hartford—The Ainslee Machine & Tool Co., Jefferson Ave., has awarded the contract for the erection of a 1 story, 50 x 106 ft. factory, to J. M. Woolley. A steam heating system will be installed in same. Total estimated cost, $30,000.

Conn., Hartford—The Lenz Bakery, 1261 Main St., will install a steam heating system and is in the market for two new boilers in connection with the 2 story, 64 x 68 ft. bakery on Windsor St. Total estimated cost, $45,000.

Conn., New Haven—The New York, New Haven and Hartford R.R., Meadow St., will install a vacuum system in the proposed 1 story, 75 x 151 ft. electrical draft building in Cedar Hill Yards. E. Gagel, Ch. Engr.

N. Y., Buffalo—The Monarch Knitting Co. plans to build a dye and boiler house adjoining its plant at Doat and Rustic St. and Lonsdale Place.

N. Y., New York—The Oliverage Co., 510 5th Ave., has awarded the contract for the erection of a 3 story, 50 x 120 ft. loft and store building, to Champaign & Silverman, 104 West 42nd St. A steam heating system will be installed in same. Total estimated cost, $65,000.

N. Y., Oswego—P. Raby, Arch., 23 North Cayuga St., is receiving bids for the erection of a 1 story, 75 x 200 ft. foundry for G. J. Hessler, Mitchell St.; foundry equipment and conveying apparatus will be installed in same. Total estimated cost, $50,000.

N. J., Bayonne—The United Industries plans to build a 3 story, 91 x 190 ft. Y. M. C. A. building on Ave. E and East 22nd St. Project includes the installation of a steam heating system. Total estimated cost, $300,000.

Penn., New Kensington—The New Kensington Ice Co. plans to erect a 2 story, 50 x 125 ft. refrigerating plant at 2nd St. and 7th Ave. Estimated cost, $50,000.

D. C., Wash.—The Bureau of Yards & Docks, Navy Dept., will receive bids until Oct. 14 for constructing a pumping plant, water system and tanks at South Charleston, W. Va., Specification No. 3427.

W. Va., Clay—The Clay Utility Co. plans to build 5 miles of power line to carry electric current from the Central Power Co., Hartland, to the town of Clay for illumination purposes. Estimated cost, $10,000. O. L. Hall, Engr.

N. C., Belhaven—City plans electric light improvements and is in the market for 100 h.p. crude oil engine, 90 K.V.A. engine type, 2300 volt alternator, exciter and switchboard. Wm. Platt, Durham, Engr.

N. C., Mount Airy—City Commissioners plan to erect an electric power plant. Estimated cost, $50,000.

Ky., Whitesburg—The Elkhorn-Jellico Coal Co. plans to build a power plant.

Ohio, Cleveland—The American Sheet & Tin Plate Co., 7037 Bessemer Ave., will install a steam heating system in the 1 story, 50 x 100 ft. factory which it will erect. Total estimated cost, $20,000.

Ohio, Cleveland—The Cleveland Pneumatic Tool Co., 3378 East 78th St., will install a steam heating system in its 1 story 52 x 165 ft. factory on East 78th St. Total estimated cost, $25,000.

Ohio, Cleveland—The Cleveland Worsted Mills, 6730 Broadway, will install a steam heating system in the proposed 3 story, 62 x 164 ft. woolen mill which it will erect. Total estimated cost, $100,000. G. S. Rider, 512 Century Bldg., Engr.

Ohio, Cleveland—The Van Dorn Iron Works, St. Clair Ave., will install a steam heating system in its new 120 x 120 ft. factory. Estimated cost, $30,000.

Ohio, Cleveland—The Western Reserve University, 10940 Euclid Ave., will install steam heating systems in the 2 story, 100 x 200 ft. dormitories which it plans to erect. Total estimated cost, $150,000.

Ohio, Hamilton—The Hamilton & Rossville Hydraulic Co. and the Ford Co., plans to erect an electric power line along certain city streets.

Ohio, Toledo—H. Rosen, 2251 Smeed Ave., will install a steam heating system in the proposed 3 story, 70 x 100 ft. office and warehouse. Total estimated cost, $70,000.

Ohio, Toledo—The Toledo Screw Products Co., 2240 Smeed Ave., plans to install a steam heating system in t h e proposed 1 story, 40 x 200 ft. factory.

Mich., Detroit—The Solvay Process Co., Jefferson Ave., plans to build a 72 x 80 ft. electric power plant. Estimated cost, $35,000. F. F. Bont, Engr.

Wis., Racine—Board of Public Works will install a steam heating plant in the 3 story City Hall Building which it plans to remodel. Total estimated cost, $60,000. A. A. Connolly, Racine, Arch.

Wis., Sturgeon Bay—The Universal Shipbuilding Co. plans to build a 1 story, 120 x 150 ft. boiler shop. H. Reisen, Pres.

Kan., Scranton—City plans an election Oct. 19 to vote on $12,000 bond issue for electric plant.

Kan., Topeka—City is in the market for two low duty pumps toadd to the water system.

Wyo., Riverton—Frank E. Kistler, 765 York St., Denver, Colo., plans to construct and operate a gas and light plant here.

Mo., St. Louis—The Dielectric Manufacturing Co., 224 South Vandeventer St., plans to convert 10 flats at 224-242 South Vandeventer Ave., into factory for chemicals and insulating material; equipment including electric boilers will be installed in same.

Mo., St. Louis—The Polar Wave Ice & Fuel Co., Grand and Oliver St., plans to build an ice plant at 4735 Eastern Ave. Estimated cost, $200,000. H. G. Clymer, Wainright Bldg., Arch.

Ark., Clarksville—The Johnson & King Coal Co., 311 Barnes Bldg., Muskogee, Okla., is in the market for a 75 h.p. electric hoist to be installed in its plant here. R. R. Brader, Vice President.

Ark., Sparkman—E. Hearn plans to reconstruct electric light plant which was destroyed by fire.

Okla., Duncan—City voted $30,000 bonds for power plant. Benham Engineering Co., 1300 Colcord Bldg., Oklahoma City, Engr.

Idaho, Idaho Falls—The City Council plans to install another power unit at the hydro-electric plant.

Wash., Seattle—The J. F. Duthie Shipbuilding Co., 3262 11th Ave., plans to build a 1 story, 93 x 209 ft. punch and boiler house. Estimated cost, $7,000.

Wash., Seattle—The Oregon Boiler Works, 3493 Klickitat Ave., will build a 1 story, 54 x 80 ft. boiler house. Estimated cost, $6,000.

Wash., Seattle—Skinner & Eddy Shipbuilding Corp., 1201 Railroad Ave., will build a 2 story, 100 x 420 ft. power shop. Estimated cost, $50,000.

Cal., Los Angeles—The Department of Public Service will soon award the contract for high voltage transformers for power plant. Chief Electrical Engr., No. 2. E. F. Scattergood, 645 South Oliver St.

Que., High Falls—The International Nickel Co., Copper Cliff, Ont., has awarded the contract for the erection of a new power dam at Big Eddy, near here, to Fraser, Brace & Co.

Ont., Amherstburg—The City is in the market for a 25 cycle transformer. W. F. Park, Mayor.

Ont., Chesley—The Chesley Chair Co. is in the market for a 20 to 35 hp. motor, 3 phase, 60 cycle, 220 volts; also a vacuum pump.

Ont., Craigmont, (Renfrew P. O.,)—The Conigas Mines, Ltd. St. Catherines, plans to build a plant here for the retreatment of feldspar tailings and is in the market for crushing machinery, power machinery, transmission equipment, building material, etc. F. D. Reid, Cobalt, Engr.

Ont., Fergus—The Electric Commissioners are in the market for a new transformer to replace the one recently destroyed by fire. Thomas N. Wansbrough, Clerk.

Ont., Galt—The City Council plans to build an addition to its electric plant. Estimated cost, $25,000. W. H. Fairchild, Engr.

Ont., North Bay—H. J. McAusland, Engr., is in the market for a pump direct-connected to gasoline engine capable of delivering 1,500 imperial gallons against a head of 280 ft.

Ont., Toronto—D. McLean, 27 Mountainview Ave., is in the market for two 80 h.p. boilers, having 125 lbs. pressure; one double drum hoist without engine, and one 20 x 40 left hand heavy duty engine.

Man., Winnipeg—The Radford-Wright Co., Phillips St., plans to build a power house. Estimated cost, $6,000.

Sask., Rosthern—The Water Commissioners will install additional electrical equipment in its power plant for lighting purposes. Mayor Fleury, Chn.

Alta., Grand Prairie—The town has carried a by-law for the erection of an electrical plant. Estimated cost, $40,000. R. L. Michaels, Mayor.

CONTRACTS AWARDED

Mass., Chicopee—The Bay State Storage Co., 385 Liberty St., Springfield, has awarded the contract for the erection of a 1 story, 20 x 30 ft. boiler house, to E. J. Pinney, 264 Main St., Springfield. Estimated cost, $8,500.

Conn., New London—The Red Cross has awarded the contract for the installation of a heating and power system in the 2 story, 41 x 82 ft. hospital on Jefferson Ave., to R. B. Wilson, Jr., 14 West Broadway, Newport, R. I.

Pa., Greenville—The Board of Education has awarded the contract for the installation of a heating system in the new Penn High School building, to the Mercer County Heat, Light and Power Co.

D. C., Wash.—The Bureau of Standards, Department of Commerce, has awarded the contract for the erection of a 2-story, 50 x 150 ft. dynamometer building, to the Turner Construction Co., Woodward Bldg.

D. C., Wash.—The Bureau of Yards & Docks, Navy Dept., received low bids for installing a heating system in Yacht Club at Cape May, N. J., from Adams Britz & Co., 1761 Park Ave., New York City, N. Y., $4,241 (40 days); Muller & Brady, 210 East 38th St., New York City, N. Y., $4,585, (45 days).

D. C., Wash.—The Bureau of Yards & Docks, Navy Dept., has awarded the contract for the construction of heating water supply and electric system, to Adams, Britz & Co., 1761 Park Ave., New York City, N. Y., $142,800, 59 days.

Ohio, Cincinnati—The Board of Education has awarded the contract for the erection of a temperature regulation and heating system, to the Southern Heating Co., St. Louis, Mo. Estimated cost, $135,187.

Iowa, Elkhart—City has awarded the contract for the erection of a transmission line, sub-station and distributing system to F. E. Tedford, Gowrie. Estimated cost, $7000. Noted Aug. 6.

Iowa, Missouri Valley—City Clerk has awarded the contract for sinking two 12 in. wells, each 90 ft. deep; furnishing and installing two pumps, with engines, to deliver water from these wells to distributing reservoir against a head of 265 ft., to E. C. Archibald, Council Bluffs. Estimated cost, $13,570. Noted Oct. 1.

Cal., Coalinga—C. T. Walker, City Clk., has awarded the contract for the installation of a gas engine in the auxiliary water system, to the West Coast Gas Engine Co., 420 East 3rd St., Los Angeles. Noted, Sept. 10.

Calif., Martinez—City let contract for furnishing two triplex, single acting pumps, to the Fairbanks-Morse Co., 651 Mission St., San Francisco, Cal. Estimated cost, $6015.

N. S., Halifax—The Sacred Heart Convent has awarded the contract for the erection of a power house and coal cellar, to the Nova Scotia Construction Co., Water St. Estimated cost, $13,000.

THE COAL MARKET

Boston—Current quotations per gross ton f.o.b. mines are as follows:

ANTHRACITE

	Circular Current		Circular Current
Buckwheat	$3.40	Boiler	$2.65
Rice	2.90	Barley	2.40

All-rail rate to Boston is $2.86.

BITUMINOUS

Bituminous, $8 to $8.75.

Pocahontas and New River, f.o.b. Boston, $8.35 to $8.90.

New York—Current quotations per gross ton f.o.b. Tidewater at the lower ports* are as follows:

	Circular	Individual		Circular	Individual
Pea	$5.50	$6.25	Broken	$6.75	$7.50
Buck.	5.10	5.90	Egg	6.65	7.40
Rice	4.65	5.10	Stove	6.90	7.65
Barley	4.15	4.30	Chestnut	7.00	7.75

BITUMINOUS

Current quotations, gross tons, based on Government prices at the mines, net ton; f.o.b. Tidewater, at the lower ports, are as follows:

	Mine Gross	F.O.B. N.Y. Gross
Central Pennsylvania (Mine run, Prepared or Slack)	$3.30	$5.45
Upper Potomac, Cumberland & Piedmont Fields:		
Run of Mine	3.08	5.23
Prepared	3.36	5.51
Slack	2.80	4.95

Quotations at the upper ports for both bituminous and anthracite are 5c. higher on account of the difference in freight rates, and are exclusive of the 3% war freight tax.

*The lower ports are: Elizabethport, Port Johnson, Port Reading, Perth Amboy and South Amboy. The upper ports are: Port Liberty, Hoboken, Weehawken, Edgewater or Cliffside and Guttenberg. St. George is in between and sometimes a special boat rate is made. Some bituminous is shipped from Port Liberty. The rate to the upper ports is 5c. higher than to the lower ports.

Philadelphia—Prices per gross ton f.o.b. cars at mines for line shipment and f.o.b. Port Richmond for tide shipment are as follows:

	Line		Tide	
	Current	One Yr. Ago	Current	One Yr. Ago
Pea	$3.75	$5.00	$4.60	$4.00
Barley	2.40	1.90	3.30	2.15
Buckwheat	3.40	2.90	4.45	3.80
Rice	2.90	2.40	3.80	3.40
Boiler	2.70	2.20	3.70	3.30

Chicago—Steam coal prices f.o.b. mines:

Illinois Coals	Southern Illinois	Northern Illinois
Prepared sizes	$2.55—2.70	$3.25—3.40
Mine-run	2.35—2.50	3.00—3.15
Screenings	2.05—2.20	2.75—2.90

Birmingham—Current prices per net ton f.o.b. mines are as follows:

	Mine-Run	Prepared Sizes	Slack or Screenings
Big Seam, Mary Lee, New Castle, Blue Creek, Brookdale, Milldale, Henry Ellen or Acmar	$2.45	$2.75	$2.40
Cahaba, Black Creek, Milldale, Carter and Durie seams, and Underwood seam in Etowah and Blount Counties, Jefferson seam in Marion, Walker and Winston Counties	3.45	3.75	3.10
Pratt, Brookwood, Nickel Plate, America, Jagger, Coal City, Jefferson (except in Walker, Marion and Winston Counties), Mt. Carmel seam or upper branch of Big Seam on Birmingham Mineral south of Bessemer	2.85	3.05	2.45
Helena and Harkness seams and coal mined by No. 2 Belle Helen, and Youngblood seam	2.90	3.20	2.70
Climax seam near Maylene.			

St. Louis—Prices per net ton bituminous coal f.o.b. mine today as compared with a year ago are as follows:

	Williamson and Franklin Counties, Mt. Olive and Staunton	Standard
Prepared sizes (lump, egg, nut, etc.)	$2.55@2.75	$2.40@2.70
Mine-run	2.35@2.50	2.20@2.30
Screenings	2.17@2.32	1.50@1.50

Williamson-Franklin rate to St. Louis is $1.10.

other rates p. 95.